BRITISH SHIPBUILDING FIGURES. See p. 337.
NAVAL ARCHITECTS' MEETING—PAPERS AND DISCUSSIONS. See pp. 339–365.

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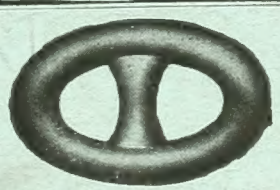
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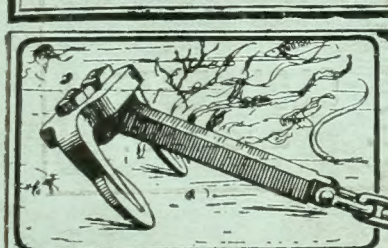
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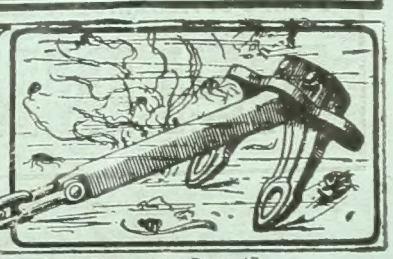

Alphabetical Index of Advertisers, Page 52. 4 w. Classified Index to Advertisements, Page 47.

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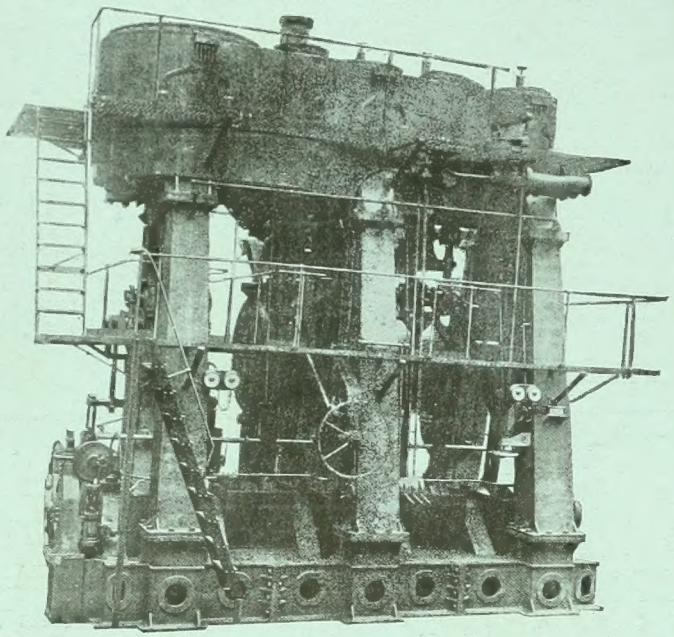

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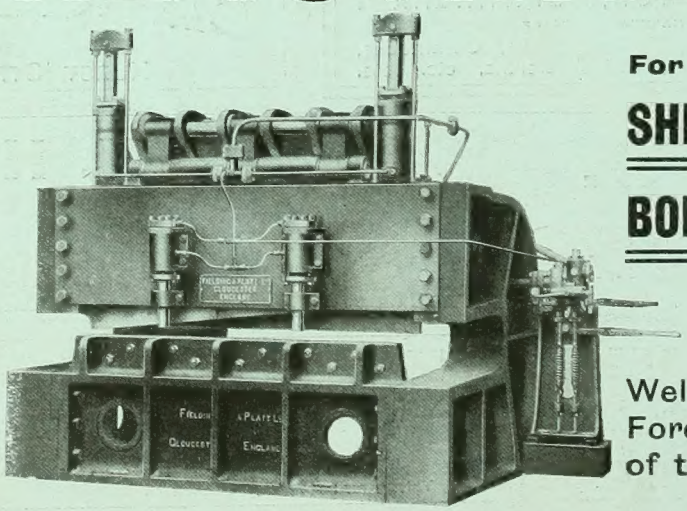

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VOL. XI.] THURSDAY, MARCH 28, 1918. [No. 13.

CONTENTS.

EDITORIALS:
- Dutch Shipping 333
- The Coasting Trade..... 333
- The Port of Swansea..... 333
- New Requisitioned Vessels Clause 333
- Greek Insurance Companies..... 334
- The Government and Port Dues 334
- Japanese Shipping Development 334
- British Interests in China..... 334
- Employers and Labour Affairs..... 334
- Admiralty and Shipbuilding..... 335
- Swedish Shipbuilding..... 335
- Independent Salvage Pumps..... 335
- Super Power Stations..... 335
- Shipbuilding Prospects..... 335
- The Naval Architects' Meeting.... 336
- The Shipbuilding Situation..... 337
- Publications Received..... 338

INSTITUTION OF NAVAL ARCHITECTS:
- Standard Cargo Ships..... 339
- Problems of the Future in the Design and Construction of Merchant Ships..... 342
- The Most Suitable Sizes and Speeds for General Cargo Steamers..... 345
- A Preliminary Survey of the Possibilities of Reinforced Concrete as a Material for Ship Construction 350
- Annual Meeting..... 353
- Some Notes on the Importance of Research in Marine Engineering 360
- Effect of the Longitudinal Motion of a Ship on Its Statical Transverse Stability..... 362
- The Iron Carbon Equilibrium Diagram and Its Practical Usefulness..... 363
- Stress Distribution in Bolts and Nuts 363
- Reinforced Concrete Vessels..... 363
- On the Design and Construction of Self-Propelled Reinforced Concrete Sea-Going Cargo Steamers, now Building in Great Britain..... 364

ILLUSTRATED:
- Merchant Tonnage and the Submarine 367

MISCELLANEOUS:
- Swedish Shipbuilding Steel..... 338
- Financial Facilities for Trade..... 338
- Austrian Shipping Problems..... 338
- Shipbuilding and Admiralty Control..... 368

GENERAL NEWS SECTION..... 369

SHARE TABLE. 372

AS the Dutch Government has been unable to come to an agreement with the Allied Powers in regard to the terms on which Dutch shipping lying in Allied ports can be brought into use, America and Britain have intimated that they will proceed to requisition these vessels in the exercise of what is technically known as the right of augury. We should have preferred that the employment of this portion of Dutch shipping should have been attained as the result of bargaining. But Holland has been held back by the menace of an unscrupulous and implacable Germany. The restrictive clauses, placing war material outside the cargoes which would be carried, were impossible in these days. We have had no alternative but to fall back on our legal powers under the right of augury—to use "such property of subjects of neutral states as retains its neutral character from its temporary position on belligerent territory." That right is undoubted in international law, and was exercised by the Germans in 1871, when they seized and sank British colliers in the Seine at Duclair to block the passage to French gunboats. The best modern practice, as laid down in the United States Naval Code, is to give prompt and ample compensation to the owners of neutral vessels. That course is being followed by the British and American Governments, and the Dutch owners will be liberally treated in the matter of hire and replacement.

Dutch Shipping.

Naturally, no interference is or can be contemplated with Dutch ships lying in Dutch ports. These are, it need scarcely be pointed out, not subject in any legal sense to our decision. They are believed to be sufficient for the purposes of the supply of Holland, and Lord Robert Cecil, the Minister of Blockade, gives a guarantee that if they leave Dutch ports they will not be made the subject of requisition. Moreover, considerable quantities of grain in America will be placed at the disposal of Holland, and every facility given to the vessels transporting it. The real quarrel of the Dutch is with German violation of the freedom of the high seas.

One of the reasons for the drastic rationing of coal which is to be adopted, particularly in the southern parts of England, is the withdrawal from the coasting service of a number of steamers. These vessels have been carrying, in round figures, three million tons a year. The railways will be able to transport only half this amount, and there is no alternative but to cut down severely the quantity of coal used for gas and electric undertakings, and to impose restrictions on the uses of coal. Sir Albert Stanley, the President of the Board of Trade, explained the outlines of the scheme in the House of Commons last week. He indicated also that there would be a considerable withdrawal of men from the mines. It appears that it is not only the coasting trade in coal which is to suffer by the withdrawal of steamers. As questions in Parliament indicate, some of the vessels carrying on services to Irish ports are affected. It is stated by Sir L. C. Money that they are to be withdrawn in order to meet an urgent Allied requirement.

The Coasting Trade.

Swansea, as a port, has suffered in trade during the war by the restriction on imports and exports, and that fact brings in its train difficulties of which the Harbour Trust are seeking a solution. The Board of Trade has been approached, as our news columns have duly recorded, and last Thursday the position of the port was raised in debate in the House of Commons by Mr. T. Williams. He pointed out that complaint had arisen because certain other ports in the Bristol Channel received financial support from the Government, and the important docks at Swansea did not get any. The Board of Trade reply was at least sympathetic in form. Mr. Wardle, the Parliamentary Secretary, promised careful consideration and inquiry, which he hoped would be followed by immediate action. Other ports besides Swansea are experiencing special difficulties just now, and the national interest demands that exceptional treatment should be temporarily accorded to them in these abnormal times. We rather fear that in some periods of the war, the central authority has not been alive to its full responsibilities in regard to them. That was the impression left, for instance, by the controversy relating to harbour dues and Government vessels.

The Port of Swansea.

After considerable deliberation, underwriters have agreed to a standard clause for use in the insurances of vessels which are likely to be requisitioned by the Government. The clause provides for the payment of additional premiums when warranties have been broken, provided that notice is given to underwriters immediately the owner learns of the deviation. It also provides for the suspension of the policies when the risk is taken over by the Government, both under the bare ship charter or otherwise. The most interesting portion of the clause, however, is that which deals with returns in the case of loss, which reads as follows:—"Should the vessel be lost by marine perils during the suspension, it is agreed to return premium to expiry date of policy; but if lost by perils excluded by the 'F.C. & S.' warranty to return premium to date of loss

New Requisitioned Vessels Clause.

or to date when vessel would have been returned by the Government, whichever be the later date. No return premium, however, to be paid until the expiration of the policy, whether by the effluxion of time or otherwise." It will be noted that the *Easby Abbey* ruling is adhered to in its strictest interpretation. The provision for the return up to the date of loss or the date of the return by the Government leaving no doubt as to this. The general features of the clause run on the lines of the agreements which have been in use for some time now, and there will be practically no change in the custom which has become established in dealing with these cases. It is satisfactory, nevertheless, to have a standard form for use in the frequent occurrence of arranging the insurances of requisitioned steamers.

Greek Insurance Companies.

We have recently seen a list of new insurance companies of Greek origin, some dozen in number, which have been established with the intention of writing marine business. Presumably these companies will look for the greater part of their business to their national mercantile marine trade, and, since this is of some dimensions there should be a wide scope for operations open to a well organised business. The position of Greek insurances is somewhat singular, however, and it is difficult to believe that the owners will desert the British market, which has served them so well in the past, for their own companies, however well founded, without some irresistible inducement. We refer principally to the Hull market, of course. Here Greek business has been in the hands of a comparatively few firms of brokers whose wide experience enables them to obtain terms agreeable to their clients. These terms vary in most cases from those affecting British owned vessels by the amount of liability for Particular Average left at the owners' risk. It has been found that the Greek owner is generally the better client if he has something at stake himself, rather than having the whole of the risk covered by insurance. Therefore, in many insurances, a warranty is inserted to the effect that some of the average risk, generally 25 per cent., is at the owners' risk. On these conditions it has been found that a steady profit can be obtained from these risks, and since a profit to the underwriter is shared by the owner who shares the risk, it is not surprising that the conditions find general acceptance in reputable Greek shipping circles.

The Government and Port Dues.

Trouble has, we hear, again arisen between the Treasury and the harbour authorities throughout the United Kingdom in regard to the payment of dues. A year or so ago, it may be remembered, the Government claimed the free use of the ports under the Harbours, Docks and Piers Act, of 1847, for all ships, naval and mercantile, under its control, apparently attaching no importance to the fact that the waterways, harbours, and warehouses had not been created out of national funds, and that it required a considerable expenditure every year to maintain their efficiency, apart from heavy interest charges and labour expenses. It based this refusal on the ground that the measure in question embodied an ancient custom that the King's ships should not pay charges for the use of the ports, although during the South African war no such question was at issue, all the claims for accommodation being met without demur. After a good deal of agitation on the subject, and several conferences, a compromise was arrived at, the Government offering 75 per cent. of customary dues on vessels not owned by the Crown, 75 per cent. on ships owned by the Crown, and 100 per cent. of the dues on goods, stores, &c. The existing difficulty has, we believe, been caused by a refusal to pay on tonnage spaces not included in the measurements ordinarily used for cargo, but now being applied to this purpose in consequence of the shipping shortage. The suggestion has been made that the question should be referred to arbitration, and this is the line of action that will probably be taken, although the attitude of the Treasury certainly does not encourage harbour authorities to carry out extensive improvements in the national interest so as to attract trade in the post-war period.

Japanese Shipping Development.

We have frequently drawn attention in these columns to the developments which are being made by various shipping companies consequent upon the withdrawal of British services to more essential work in connection with the war, and have urged the necessity of a fuller realisation of the competition which will await British shipping interests on a return to more normal conditions. The latest development to which attention should be drawn is that of the Osaka Shosen Kaisha, one of the largest of the Japanese shipping companies, who, it is officially announced, has decided to inaugurate a new regular freight service between Bombay and Marseilles *via* the Suez Canal, in connection with its existing service between Japan and Bombay. Cargo will be accepted for transport from Japan to French ports and *vice versa* under the company's own bills of lading. At first the service will be a monthly one, and three steamers of about 4,000 tons are mentioned as having been scheduled to leave Japan at the beginning of April and the two succeeding months, but undoubtedly the intention of the company is later to put larger vessels on the route and to develop the service. It is of interest to note that already, besides its Indian line, the company maintains regular services between Japan and Australia, South Africa and North and South America.

British Interests in China.

During the past three or four years the cloud of war has somewhat obscured events in the Far East generally, and certain developments that were anticipated when hostilities began have not, so far as can be ascertained, taken place. On the whole it cannot be said that the outlook for British trading and, therefore, shipping interests in that part of the world has, in the meantime, improved. About the beginning of 1914 there was a good deal of agitation over Japanese efforts to obtain a footing in our sphere of influence on the Yangtse, and, in fact, action by the Foreign Office was contemplated. We now hear of the sale by the West River Company, which is owned by such essentially British firms as Jardine, Matheson & Co., and Butterfield & Swire, of their four steamers *Sainam*, *Lintan*, *Nanning* and *Sanui* to a Chinese syndicate at Hong Kong. Why? There is abundant evidence that the transaction, which may, of course, involve nothing serious, is the cause of grave concern in British circles in China. Not only so, but the United States Consul-General at Hong Kong, in a report to the State Department, Washington, has drawn special attention to it, remarking that the abandonment of the service, which has for many years been an important feeder for the China Navigation and Indo-China companies, may indicate a decline in the British shipping monopoly and prestige in Far Eastern waters, more particularly as the West River country has been peculiarly within the control of British firms that have been pioneers in the trade and have earned all they had in it. Chinese shipping is, apparently, on the eve of an important expansion, which the seizure of enemy steamers will, no doubt, facilitate to some considerable extent.

Employers and Labour Affairs.

Some time ago we alluded to the heavy calls which labour affairs are making on the time and attention of heads of great industrial establishments, and suggested that before long directors would have to be appointed exclusively to attend meetings of employers' associations and negotiate with the trade unions. These labour directors would, we said, keep in constant touch with the firm's workpeople and, generally speaking, organise the relations of masters and men. One or two correspondents have

written to us on the subject, and while they are in agreement with our view that Labour affairs might profitably be better organised from the point of view of the average industrial establishment they foresee objections to our proposal. The most important of these objections is that, as at the majority of conferences important and far-reaching decisions on questions of general policy have to be taken, the head of the business must himself attend. We are not in disagreement with the view; on the contrary, we admit that the arrangement is an excellent one—provided the head of the business is kept well-informed by an organisation in close association with the workpeople. In some places there are highly developed organisations of the kind, and, besides keeping the director-in-chief informed, they relieve him of a great deal of local work. As our object in raising the question was to relieve the managing director of work of minor importance, we are content. Obviously, it is a great deal to the good if the big men are left free to concentrate on big things.

Admiralty and Shipbuilding.

When the shipbuilding crisis was in its most acute stage, it was seriously argued in several quarters that shipbuilding and the shipyards ought to be taken out of the hands of the Admiralty. "Its business is," it was said, "to sail ships—not to build them." To what extent the falling-off in the output of merchant ships is due to the Admiralty habit of—let us call it—thoroughness is not easy to tell. But even if the decline were wholly due to the cause indicated, the argument would still be unsound that the Admiralty ought not to be in control of shipbuilding during war. Maritime strategy assumes, to begin with, that all existing shipbuilding resources are available to it, and makes its plans accordingly. These plans naturally include provision for exercising the control of maritime communications as well as provision for securing the control, and if in one or other of these directions the provision is more or less than it ought to be the strategy is to that extent bad. British maritime strategy cannot fairly be said to be defective, seeing that the falling-off in output was from a standard to which it was working. And even if the root of the trouble were the average naval technical expert's excess of zeal in the interest of science, there would be no good ground for taking mercantile shipbuilding away from the Admiralty. The cure would be to reduce the average technical expert's excess of zeal, and in that way ensure progress with the work in hand, according to schedule.

Swedish Shipbuilding.

According to *Schiffbau*, Swedish shipyards have not been extended to any considerable extent during the war. Full use has simply been made of existing facilities. Much more would have been done but for the severe shortage of materials. The tonnage of steel vessels launched has increased slowly but steadily, viz. in 1915, 20,000 gross tons; in 1916, 25,000 tons; in 1917, 29,000 tons. War vessels built during 1917 included the *Dronning Victoria*, 7,500 tons, by the Gothenburg Works, and two 400-ton torpedo boat destroyers by the Lindholmens yard. In addition, there were a certain number of submarines. About one-half of the total merchant tonnage built in 1917 was delivered by Gothenburg yards; Helsingborgs yard, 1,000 tons; Kockums, 1,400 tons; Limhamns, 1,500 tons; and Oskarshamns, 3,600 tons. Newly founded yards have not yet made deliveries of any importance. The Solvenborgs & Brodin yards (Gefle) have been enlarged. Nothing definite can yet be said concerning the prospects of ferro-concrete shipbuilding in Sweden, but at least two yards (in Stockholm and Malmo) have taken up the new process. The largest merchant vessel yet built in Sweden (the *Bullaren*, a Diesel ship) was completed during 1917, and the same yard which built this vessel and its motors has seven sister vessels on order with a total of 40,000 tons. All Swedish yards are inundated with orders and have splendid prospects, provided that the difficulties of materials supply can be overcome. Swedish steel works are unable to supply the whole demand, nor is it likely that they will be able to do so in the immediate future. Orders in hand are estimated to total 200,000 to 300,000 gross tons, that is, about ten times the tonnage built in 1917.

Independent Salvage Pumps.

We referred in these columns recently to the advisability of having on board every vessel an independent salvage pump situated well above the water-line, and driven by an internal combustion engine so as to render it available for service when from any cause the vessel is in danger of being flooded and the steam supply fails owing to damage in the boiler room, thus rendering the ordinary pumps of no avail. That an internal combustion engine is eminently suited for this purpose will not be denied, but there is a danger of fitting too much emergency machinery, so that in time of accident, owing to its very magnitude and complexity, it fails to meet the purpose for which it was installed. It has been made compulsory for all vessels to carry an emergency lighting dynamo to generate sufficient electrical energy to operate the wireless set and light the essential parts of the boat when the main dynamos have been put out of action, and it would be a rather simpler arrangement to install an emergency dynamo of rather greater capacity, so that current from it could be utilised to drive a motor which in its turn would drive the salvage pump. In this way an emergency salvage pump of any desired capacity could be carried which would be instantly available for service as soon as the emergency lighting and wireless set had been started up.

Super Power Stations.

One of the most important considerations in the economical running of a shipyard is a cheap supply of power, and any attempt which is made with the object of providing such a supply must be received with sympathetic consideration by all shipbuilders. The matter has been dealt with by the Coal Conservation Committee appointed by the Ministry of Reconstruction in a report on the electric power supply in Great Britain in which the erection of large super generating stations is advocated, wherein shall be installed large generating units capable of producing electric power so cheaply that it will lead to a large increase in the amount of power used for industrial purposes, the power being supplied to existing small distributing systems which would be interconnected to form one large distributing system. Reference is made in the report to the North-East Coast district where the average price paid for electrical energy is less than ½d. per unit, the district being served by a group of power companies from one inter-connected distributing system. It is of interest to note that the Mersey Power Company is in negotiation for a site for the erection of a super power station on the lines suggested by the Coal Conservation Committee, and that the Ministry of Munitions has agreed to make a loan of £300,000. This should result in a supply of cheap electrical power in the Liverpool area, with a corresponding development of the shipbuilding and ship-repairing industry on the banks of the Mersey.

Shipbuilding Prospects.

Those not engaged in shipbuilding have been most venomous in their attack on shipyard workers as a whole. Undoubtedly the output for January and February was most disappointing, but in Scotland particularly a large tonnage launched was not to be looked for. What with the holidays, unrest owing to the question of the 12½ per cent. advance, and severe weather conditions, a small production was inevitable. The main cause of the unsatisfactory state of affairs has now, however, been removed, and those now in charge of merchant shipbuilding and repairing are men who are intimately in touch with shipyards, and the spirit of them. The evil influence of alterations in the designs of ships when they are under construction cannot be over-estimated, and the

putting up and tearing down policy must at all hazards be overcome. That our shipyards are capable of the best of work is beyond dispute. In certain places the production of destroyers, for example, has been proceeding with a regularity which would cheer the hearts of people to know. This has been due to the management being allowed to proceed, unfettered, to work on a system of methodical production, which has proved to have been admirably conceived, and is well executed. Had the so-called "standard" ships been such, not in name only but in actuality, each yard entrusted with their construction could have developed a system whereby the maximum output could have been obtained. The alteration of ordinary cargo ships to oil tankers has lost to the nation thousands of tons of shipping, but it is to be hoped that the days of gross mismanagement of this, the most important of all branches of national industry, are over.

THE NAVAL ARCHITECTS' MEETING.

THE papers read at the meetings of the Institute of Naval Architects, held in London on Wednesday, Thursday and Friday of last week, while they did not produce anything of particularly outstanding merit, can undoubtedly be regarded as having been up to the high standard of excellence set during recent years. The subject of warship design, and in fact anything relating to naval construction, was entirely absent from the papers, but as might have been expected the standard ship came in for a considerable amount of consideration, and as a witness to the importance with which concrete is regarded by naval architects, no fewer than three of the twelve papers which formed the programme of this year's proceedings dealt with different phases of the subject of reinforced concrete.

The opening meeting was presided over by the Earl of Durham, who was again elected to fill the presidential chair for the ensuing twelve months. In a characteristic address he drew attention to the shipbuilding crisis and declared that he did not think he was misinterpreting the views of some of his North of England friends when he said that they attributed much of the trouble and delay not to disputes between employers and workmen, not to unwillingness or lack of patriotism on the part of the workmen, but to inexpert interference and the hustling methods of Government officials. His advice to the Government was "Don't jostle," and this point of view predominated throughout the entire proceedings whenever the subject was under discussion.

Pride of place was given to Sir George Carter's paper on "Standard Cargo Ships," in which he justified the standardisation programme of the Government. Sir George admitted that there had been delay in the production of standard ships in spite of all the arrangements made to expedite their construction; the chief cause of the delay being shortage of steel; he thought that it might be claimed, however, that the policy of the Government was being justified, and would in the future be justified to a much greater extent. As might have been expected, the paper, which we reproduce in full elsewhere in this issue, gave rise to a long and interesting discussion in which many authorities on the subject of ships, both from the constructors' and the owners' point of view, took part. Sir Alan Anderson, the Admiralty Controller, speaking as he said on the administrative side of the problem, declared that Sir George Carter's paper "absolutely answered" most of the criticism that had been raised against the standard ship policy; mistakes had been made, but in war it was necessary to act more rapidly and to make more mistakes than in peace. Mr. S. W. Barnaby made the interesting announcement that the recommendations of the committee appointed by the Council of the Institution to inquire into the effect of mines and torpedoes on merchant ships had for the most part been embodied in the designs of the standard ships. Of the others taking part in the discussion, it is of interest to note that Mr. J. W. Isherwood severely criticised Sir George Carter's remarks on the limitations of the unsinkable ship.

It was found necessary to have an afternoon session on the Wednesday, when Mr. Anderson presented an extremely interesting paper on "The Most Suitable Sizes and Speeds for General Cargo Steamers," in which he analysed the problem from the point of view of the various trades in which steamers might work, taking care to incorporate as far as possible every variable which might affect his solution of this problem of many variables. The discussion which followed was proof enough that shipbuilders are very much alive to the importance of suitable sizes of steamers for particular trades, and that after the war a rigid adherence to the principles of standardisation will not find very great favour.

On somewhat similar lines, but dealing more with the details of construction, were the two papers read on Thursday morning. These were read one immediately after the other, and the subsequent discussion was allowed to deal with both. Mr. Abell considered some of the problems of the future in the design and construction of merchant ships, and urged the importance of careful study and research into the many problems which face the shipbuilder, drawing particular attention to the need for careful study of labour processes with a view to increasing the output of labour and of disposing material to ensure a minimum requirement of labour. Mr. Seaton's paper was in a similar vein, but dealt more particularly with the need for research in marine engineering.

Of a more theoretical and scientific nature was the paper on the "Effect of the Longitudinal Motion of a Ship on its Statical Transverse Stability," which was submitted by Mr. G. S. Baker and Miss E. M. Keary, in which was given the results of a number of experiments carried out, the object of which was to measure the effect of longitudinal motion on the transverse stability of some typical forms and to determine when and why this effect becomes of importance. Of a similar nature was Mr. Robb's paper in which he considered the shearing force and the bending moment acting on the structure of a ship when supported at different positions by waves, and in which it was found that the maximum values of the bending moment occur over a very short range. The subject of stress distribution was also considered by Mr. Stromeyer in a paper on the stress distribution in bolts and nuts, in which as a result of some ingenious investigations he was able to explain the cause of many failures of bolts and nuts and to suggest simple remedies.

Professor Carpenter contributed an extremely interesting paper on the "Iron Carbon Equilibrium Diagram and its Practical Usefulness." These diagrams, obtained either by thermal analysis or by microscopic examination of a surface of the material, are of great value in determining the properties of steels of various qualities and also in the development of the processes of annealing, tempering, &c., and since the most important material of both the shipbuilder and the marine engineer is steel, the paper was of considerable interest to the Institution.

Finally, we must draw attention to the three papers on the subject of reinforced concrete. Major Denny treated the subject from the general standpoint in his preliminary survey of the possibilities of reinforced concrete as a material for ship construction and presented the *pros* and the *cons* of the question for the use of this material in preference to steel. Mr. Pollock, in his paper on "Reinforced Concrete Vessels," discussed the cost and time of construction of vessels of 300 tons, 500 tons and 1,000 tons d.w. in comparison with similar vessels built of steel or of wood, and he drew particular attention to the effect on both the cost and the time factor of the repeat orders. The details of construction of 1,150 tons d.w. self-propelled reinforced concrete sea-going cargo steamers were considered by Mr. Owens-Thurston in his paper, in which he gave particulars of vessels building at Barrow-in-Furness. While these three papers were of necessity limited in their scope by the restrictions imposed by the circumstances of the time, even so they represent a wealth of knowledge on the subject of reinforced concrete ship construction, and their inclusion in this year's programme indicates that the Institution of Naval Architects is determined

to remain in the foremost rank of the societies dealing with problems of ship design and construction, no matter what innovations and changes may occur. Having thus set their seal on the subject, it may be assumed that the reinforced concrete vessel is definitely assured of its place beside vessels built of steel or wood as a scientific and commercial success.

THE SHIPBUILDING SITUATION.

THE statement of Sir Eric Geddes on the shipbuilding situation left the House of Commons last week still in a state of anxiety. We now have in the frank, brutal figures of tonnage the official record of our losses until the end of last year. Perhaps they are no worse than those engaged in shipping expected, but we now know that up to the end of 1917, the world's tonnage, exclusive of enemy-owned vessels, has suffered a net diminution of 2,500,000 gross tons, and that on British tonnage there has been inflicted a net loss of 3,500,000 tons, representing 20 per cent. on a total of 18,000,000 tons. This result has been reached after setting off new construction and enemy ships captured, against the sinkings and losses by war and marine risks. The losses are still proceeding at a greater rate than the replacement of tonnage in yards. We lost on an average 261,000 tons per month during the last quarter of 1917, and built 140,000 per month. That is a deficiency of 121,000 tons per month, and in January and February our output seriously declined. A more serious calamity than a continuance of diminished production of ships could scarcely be imagined, and this was undoubtedly the feeling uppermost in the minds of the members of the legislature as they heard the statement of the First Lord. It would have been deplorable indeed if this vista of events had not roused the critical spirit of the House, and it is indeed likely to watch with unrelaxing vigilance the steps that are in progress to relieve the situation. One thing alone will be judged adequate, and that is the success of the measures which are now being adopted in reorganisation and in the daily routine of the shipyards. Until that success has been achieved Parliament has the duty to be critical. It accepted with approval the announcement that Lord Pirrie had been appointed Controller-General of Merchant Shipbuilding, although, indeed, there are doubts whether that great shipbuilder is being invested with the sufficiently independent powers which one in such an office at such a moment ought to possess.

Sir Eric Geddes' speech was, in the main, expository, but it necessarily dealt with points on which anxiety has been growing. The extent of our losses was only one aspect of the subject. Such matters as output, design of new ships, alterations of designs, repairs, labour supply, and organisation came within its scope. On each of these matters there is room for comment, not necessarily favourable. On the matter of losses, indeed, disappointment prevailed, after the First Lord of the Admiralty resumed his seat, that he had not given the precise and definite figures which were anticipated, but that feeling has been removed by the subsequent publication of the statistics in a parliamentary paper. These show—and the point has been made with effect by Mr. R. D. Holt—that more than half the tonnage lost since the beginning of the war was lost during the year 1917. This emphasises the fact that averages based on the duration of the war are absolutely inapplicable to the present situation, and these ought in no way to blind us to the realities. We have to remember that twelve months of unrestricted submarine warfare have cost the world some six million tons of shipping. We are not yet out of this phase, although the indications are that the present quarter's sinkings will be lighter than those of any quarter in 1917. Sir Eric Geddes has acted wisely in publishing those figures regarding sinkings, and his proposal to give them regularly respecting subsequent quarters, although necessarily in arrear, ought to keep the measure of danger steadily before the eyes of all classes. This will be properly supplemented by the publication of the figures of output. We shall know from time to time how we are standing.

As has been often said, the problem of mercantile tonnage is two-fold. The naval side is to defeat the submarines. The industrial task is to replace lost ships. We hope all hesitations on the latter point are terminated. Changes in design have been a fruitful source of irritation, but some of the alterations in order to adapt vessels for evading submarines have, as Sir Eric Geddes rightly insists, been necessitated by the exigencies of the situation. But if we are to have the new tonnage rapidly, as we must, this process must not be made the pretext for any avoidable delay. There ought to be by this time a certain amount of reasonable finality in the designs under actual construction. The idea underlying the standard ship was to permit rapid multiplication of similar vessels. In these matters the First Lord claims the authority of expert shipbuilders behind him. What the nation wants is to see the yards going ahead unimpeded in the task of making good our losses. It is not a question of building alone. Repairs of damaged ships are just as important. It appears that the men who had been employed on naval and merchant ship repairs during the year could have produced half-a-million tons of new vessels, if their energies had been directed to that task. But it is more economical to repair than to build.

If the United Kingdom is to produce the 1,800,000 tons in 1918 which Sir E. Geddes has mentioned as within the capacity of our shipyards, the ranks of labour must be enlarged. The First Lord recognises it, but the rate at which skilled men are being withdrawn from the colours does not indicate that this vital side of the war situation has received the same recognition from the Army. These men ought never to have been taken from their skilled occupations. Both Sir E. Geddes and the Prime Minister believe that the monthly deficiency of 120,000 tons can be bridged. They appeal to employers and men to do it. We now learn from the mouth of Mr. Lloyd George that the observations of the First Lord on masters and men made on the previous occasion when he addressed the House are not to be regarded as an attack, but as an appeal to them to put forward greater efforts in the realisation of the national danger.

When we survey the whole situation of mercantile shipbuilding presented by the First Lord, we reach the conviction that the time had already arrived when a great practical shipbuilder like Lord Pirrie should be placed in charge of it. As Controller-General of Merchant Shipbuilding he is directly under the First Lord of the Admiralty, but he is not on the Board of Admiralty. Indeed, in some quarters there has been quite comprehensible criticism that Lord Pirrie has not been given independent Ministerial rank such as Sir Joseph Maclay possesses at the Ministry of Shipping. He, however, will be invited to attend the meetings of the Board of Admiralty and of the Maintenance Committee of the Board, when matters of mercantile shipbuilding are discussed. The idea is that naval and mercantile shipbuilding are so closely related in regard to the supply of materials and the resources of the shipyards that in the ultimate resort there should be concentration in one department. It may as well be frankly stated that strong suspicions prevail in some directions that mercantile shipbuilding has been unduly subordinated to purely Admiralty predilections. Lord Pirrie's influence will be directed to ensuring that the just claims of mercantile shipbuilding will have due weight. On this point it is most important to mention that a condition of his appointment is that when he feels its interests are concerned he has direct access to the Prime Minister and the War Cabinet. Lord Pirrie enjoys the very highest reputation as a shipbuilder of the widest experience and organising ability. Moreover, he is a man of immense independence and strength of character. These qualities are a guarantee that he will acquiesce in no course which will impede the output of tonnage. His appointment conduces towards confidence in the ability of the shipyards, by tremendous and well-directed effort, to overcome one of the greatest perils in our history.

PUBLICATIONS RECEIVED.

[A short notice of any publication does not necessarily preclude the subsequent appearance of a longer review.]

Spanish Self-Taught. Book I. With phonetic pronunciation. Enlarged and revised by Andrés J. R. V. García. London: E. Marlborough & Co., 51, Old Bailey, E.C. 4. 4¾ in. × 7¼ in. 150 pages. Paper cover, 1s. 3d. net; cloth, 2s. net.

Spanish Grammar Self-Taught. Book II. By Andrés J. R. V. García. London: E. Marlborough & Co., 51, Old Bailey, E.C. 4. 4¾ in. × 7¼ in. 144 pages. Paper cover, 1s. 3d. net; cloth, 2s. net.

Key to Exercises in Spanish Grammar Self-Taught. Book III. By Andrés J. R. V. García. London: E. Marlborough & Co., 51, Old Bailey, E.C. 4. 4¾ in. × 7¼ in. 32 pages. Paper cover, 7d. net.

Fees and Expenses Payable in connection with Board of Trade Surveys and other Mercantile Marine Services. Issued by the Board of Trade. London: H.M. Stationery Office, Imperial House, Kingsway, W.C. 2. Manchester: 37, Peter Street. Cardiff: 1, St. Andrew's Crescent. Edinburgh: 23, Forth Street. Dublin: E. Ponsonby, Ltd., 116, Grafton Street. 5½ in. × 8½ in. 27 pages. Price 3d. net.

SWEDISH SHIPBUILDING STEEL.

New shipyards have been founded during the war to a greater extent than in any other country, but most of these concerns are still unable to do much owing to lack of materials. Swedish steel production before the war was insufficient to meet naval requirements and imported steel was alone available for mercantile constructions. When it became obvious that little foreign steel could be imported and that only at prohibitive prices, the native steel industry was rapidly extended. Extensions now in progress at the largest iron works in Domnarvet include the utilisation of hydro-electric power and will ultimately provide for the manufacture of 100,000 tons of raw iron per annum. Two large blast furnaces are under construction. The first rolled sections for shipbuilding were made last November and large quantities of shipbuilding steel should be delivered to the Gothenburg Works this autumn. This electric steel works will soon be delivering three times as much shipbuilding steel as was used by the whole Swedish shipbuilding industry before the war.

FINANCIAL FACILITIES FOR TRADE.

In the reports of the departmental committees on after-war trade, given in the *Board of Trade Journal*, the financial facilities for trade with regard to shipbuilding and marine engineering are referred to as follows:—

With the foundation of the British Trade Corporation, a step was taken in the direction of affording to trade wider facilities for financial assistance. Its operations are as yet in the initial stage, but an indication of its possibilities is supplied by the Departmental Committees in their survey of the gaps that exist in many industries between finance on the one hand, and trade and manufactures on the other.

Written replies made by shipbuilding and marine engineering firms, and evidence given before the Shipping and Shipbuilding Industries Committee, indicated that the support afforded by financial institutions to British shipbuilders and marine engineers has been fairly good for home business, but a few cases were reported where foreign banks have given greater facilities to their customers, either with or without the support of their Governments.

The committee summarise the situation by stating that "although there are exceptions, it appears, generally speaking, that while the majority of shipbuilding firms in this country have given long credits of from one to five years, or even more, to their British customers, they have usually insisted on being paid cash in their foreign business. One witness stated that while foreign shipowners in the past paid cash, for a few years prior to the war they were asking for terms for a small portion of the contract price. Some German builders, supported by their banks, have undoubtedly been willing to take greater risks in promoting their foreign business than British shipbuilders were prepared to take, and witnesses have expressed the view that a British trade bank or banks, formed with Government support to give credit over longer periods than British banks usually do, would greatly assist in maintaining and extending British industries abroad. We entirely concur in this view, and hope that the needs of the situation will be met to a considerable extent by the British Trade Corporation which has now been set up."

AUSTRIAN SHIPPING PROBLEMS.

There are several interesting items in a report published by *Hamburger Nachrichten*, as originating from Vienna. The report was published on February 6, and runs essentially as follows:—

"The Vienna Bourse is completely under the influence of the collapse in quotations for shipping and shipbuilding shares. A few months ago shipping shares were the object of wild and—as events have proved—unjustified speculation. The cause of the present slump is the bankruptcy of the Cantiere Navale, Trieste. The works, vessels and general equipment of the company at Monfalcone were virtually destroyed by the Italians. The damage done amounted to £588,000, whereas the capital of the company was only £440,000, and there were no particular reserves. The yards at Linz and Budapest could not be drawn upon to re-establish the concern as a whole, because their receipts would, at the best, cover the working expenses. Application was made to the State for indemnity or for a capital grant, since the company was quite unable to rehabilitate itself. This assistance was not forthcoming for the reason that reconstruction of the yard and vessels would have to be commenced at once if the company were to meet the competition of other yards; but the cost of present reconstruction would be prohibitive. The net result is that the yard cannot continue its existence. Other yards, however, have great plans for the immediate future. The Austriawerft, Trieste (the former Stabilimento Tecnico) and the Cantiere San Rocco have extension schemes in hand, but there is the difficulty of the scarcity and high price of materials. New shipyards are planned in Austria and Hungary, in Dalmatia and Fiume.

"The exposure of the true position of the Cantiere Navale was accompanied by a sharp decline in all shipping quotations. The company's shares stood highest in public favour; exaggerated ideas had been formed as to their profit-making possibilities; and the shares had come to be reckoned on a par with the Skoda shares. The rude truth has forced the whole Austrian shipping market back on to a sound basis, incidentally involving a great fall in prices. All owners are involved in this readjustment, which in itself is a matter for congratulation. Bitter experience has been gained. It is to be hoped that it will end rash speculation, which certainly cannot solve the post-war problems of Austrian shipping, or facilitate the transition policy."

Industrial Reconstruction Council.—The Council is holding the second of its series of important provincial meetings at the Assembly Hall, Edinburgh, on Wednesday, April 3, at 8 p.m. The Lord Provost will preside, and Dr. Addison, Minister of Reconstruction, will be the principal speaker. The object of the movement is to arouse a widespread interest in the recommendations of the Whitley Committee for the establishment of a Joint Council in every industry, and in view of the recent publication of the second report this meeting is particularly opportune. Applications for tickets should be made to the Secretary, The Industrial Reconstruction Council, 8 Bouverie Street, E.C.4.

STANDARD CARGO SHIPS.*

By SIR GEORGE CARTER, K.B.E.

The object of the paper is to place on record the advantages of standardisation in the construction of cargo vessels as a war measure, and to give some account of the work of the Advisory Committee on Merchant Shipbuilding in the design and construction of what are now known as "Standard Ships."

Towards the end of 1915 it was apparent that very great efforts would have to be made to provide sufficient cargo tonnage to supply the needs of the country. During this year and the following one (1916) the workers in shipyards had become very much reduced. Many men had left for the Army, and many others had been transferred to work in connection with the production of munitions of war. Apart from this, the demand for war vessels of all kinds was very great, and above all the demands for steel for war purposes increased to such an extent that the supplies available were inadequate. As far as shipbuilding was concerned, steel for warships obtained priority, with the result that the supply for merchant ships was small and out of all proportion to the necessities of the case. The Board of Trade realised the position and strongly advocated the need for providing for the building of merchant ships, and, in conjunction with the Admiralty, some success was achieved, but far from sufficient to meet the increasing activities of enemy submarines. It soon became apparent that more drastic action was necessary.

In December, 1916, the New Ministries and Secretaries Act was passed, which provided for the appointment of a Shipping Controller. Sir Joseph Maclay became the Shipping Controller, and the Government decided at once that merchant shipbuilding should be under his control.

MERCHANT SHIPBUILDING ADVISORY COMMITTEE.

In December, 1916, after a conference with shipbuilders and marine engineers, Sir Joseph Maclay appointed the Merchant Shipbuilding Advisory Committee of which I had the honour to be chairman.

The first meeting of the Committee was held on December 20, 1916, and after fully considering the whole question, it was decided, in collaboration with the Shipping Controller and his other advisers, to proceed at once with an extensive building programme of cargo ships of simple design, and, as far as practicable, of standard types, both with respect to engines and hull. Although the Government's shipbuilding programme gave standardisation in shipbuilding concrete form on a large scale, standardisation had been widely discussed and urged as a practicable policy both in regard to hull and machinery, and had, in fact, taken definite shape on a smaller scale by individual firms adopting standard types of their own.

It will be as well at this stage to call attention to the great variety of merchant vessels that were under construction at this time. They totalled nearly 500, with an aggregate gross tonnage of over 1,800,000 tons. Amongst them were found fast and slow liners, intermediate passenger and cargo types, cargo boats built for special trades, fast cross-channel steamers, vessels built to carry special cargoes, "tramp" steamers, coasting vessels, and, in fact, all the varieties usually to be found in pre-war days. Even where the types were the same, individual vessels differed in size, speed and arrangements. Many of them were built for special purposes, and practically all of them embodied ideas that were peculiar to particular owners and builders. Whilst many of these specialities undoubtedly served their purpose, it is perhaps questionable whether a number of them were absolutely necessary. At any rate, since the standardisation of cargo ships has been introduced, it is generally conceded that much of it will continue to be practised even after the shipbuilding and shipping conditions have again become normal, the reason being that in many ways economy of time, material and labour are obtained by its adoption.

It can at once be stated that the greatest variations, both from the point of view of degree and number, were to be found in vessels carrying passengers. It was decided that the vessels already under construction which fulfilled to some extent the condition of being plain cargo carriers should proceed, and that standard ships should be constructed with all possible speed.

STANDARDISATION ACCEPTED.

The principle of standardisation having been accepted, it became necessary to design standard ships to meet the most urgent needs of the Shipping Controller. It was clearly desirable to limit the types as much as possible, but apart from the requirements of the Shipping Controller, the employment of the available facilities in the shipbuilding yards to the greatest advantage had to be considered. For this reason several different lengths were used for the ships, in order to use the greatest number of slips to their best advantage. The practical difficulties were great.

It has been said that if builders had been allowed to proceed in their own way and to their own designs, that the output of ships would have been greater than it has been under standardisation. Such a contention will not bear examination when all the facts are considered impartially. There has undoubtedly been delay in the production of standard ships in spite of all the arrangements made to expedite their construction, the chief element being shortage of steel. If each builder had been allowed to proceed with his own type or types of ships, this delay would have been greater, as, in addition to not getting the amount of steel required, the multitudinous sections necessary would have caused great delay in rolling at the steel mills, whose output was much increased by the simplification of sections in the standard ships, referred to later. It is not sufficient to compare the rate of production of standard ships with the pre-war rate of production. The limited supply of steel and other adverse conditions must be taken into account.

The argument that delay was caused by asking builders to construct a standard ship differing only slightly from their own type may have some justification in regard to one ship, but not to repeat ships, and it must not be forgotten that never before had a proposition been put forward to build an unlimited number of ships of similar types throughout all the yards. It is interesting also to note that in one yard a standard ship was completed in a little over six months, although the yard had never built a similar ship before. A second similar ship was also completed in practically the same time. In another yard a ship was completed, coaled, and sailed 18 days after launching.

In spite, however, of all the difficulties and the diverse opinions held by responsible shipbuilders and engineers, the policy of building standard ships has been loyally accepted by them, and I think it may be claimed that as a war emergency measure the policy is being justified, and will in the future be justified to a much greater extent.

ADVANTAGES OF STANDARDISATION.

Some of the advantages which are claimed for standardisation may be summarised as follows:—

(1) The detail design for the type can be entrusted to a builder who is conversant with that class of vessel, and whose duty it becomes to make the necessary calculations, prepare the specification and all the constructional drawings, for the information of other builders instructed to build vessels of the same type. Small details can, however, still be arranged in accordance with the ordinary practice of the individual builder.

(2) The design being in the hands of one firm, all the steel scantlings after being settled in the ordinary manner can be carefully examined to reduce the number of steel sections in the ship as much as possible. This results in producing the fewest changes of rolls at the steel works and in the rolling of much larger parcels of material to the one pattern on account of the large number of ships that are to be built to this design.

As an example of this, in the standard ships now built the number of sections are reduced to 8 or 10 as against 30 to 40 used in pre-war days for the same type of ship.

(3) All the scrieve board work would be done by one yard giving full-size frame lines, beams, side keelsons, &c., copies of which can be supplied to the other firms concerned.

(4) Steel-makers and builders can agree to divide the orders for material in accordance with the facilities of the steel-works, and having regard to proper times of delivery, so that the material first required is the first in order of delivery.

(5) Whilst there is not the same difficulty with steel plates as with sections, arrangements for the proper order of delivery can be made.

(6) With machinery the advantages of standardisation are probably more generally agreed upon, and more detailed attention is given to this in Appendix II (page 342). It may, however, be remarked here that the elaboration and production of design for auxiliary machinery and detailed fittings can be divided among the various makers, and each can arrange to undertake the whole manufacture of the details of a particular requirement.

This does not by any means exhaust all the advantages of standardisation, for after these preliminaries have been settled many benefits arise during the construction of the ships and engines. The standard ships, although not all of the same type, have many features in

* Abstract of a paper read at the Fifty-ninth Session of the Institution of Naval Architects on March 20. The discussion on this paper will be found on page 354.

common. For instance, similar sets of engines may be fitted in ships of different types, so that, apart from the large number built of each type, there is a still larger number into each of which a given set of engines can be placed. In the case of any one vessel and set of machinery built in the same yard, it may so happen that either hull or machinery will be completed some time ahead of the other. In such cases the machinery originally intended for one ship can be transferred to another, no matter where it is being built. These rearrangements are of great assistance in preventing, on the one hand, congestion of the engine works, and on the other, delay to vessels through machinery being behindhand.

The auxiliaries and fittings, including forgings and castings, being alike in vessels of each type, can be ordered in large numbers from the same maker and used in any ship or ships which may be ready to receive them.

Standard Ships.

Outline profiles and midship sections are given of some of the standard ships in Figs. 1 to 5, together with their principal dimensions and particulars. The general arrangement of the machinery as fitted is shown on the opposite page.

The first two designs made were the "A" and "B" types. Both these vessels are of the same dimensions, but the first is of the single-deck, and the second of the two-deck type; their length is 400 ft., and deadweight 8,200 tons and 8,100 tons respectively.

These types were followed by the "C" type, length, 331 ft., and deadweight 5,050 tons; and the "D" type, length, 285 ft., 2,980 tons deadweight.

The "C" and "D" types were laid down on the shorter berths as they became available, and later the "E" type was added, so that the best use might be made of berths exceeding the "C" vessels' length, but under the "A" and "B" length; the "E" type is 376 ft. in length, and 7,020 tons deadweight.

For these five types of vessels two standard types of engines only were required. The "A," "B" and "E" vessels are all fitted with the standard "A" engines. The "C" and "D" vessels again have a type of engine common to both, although in the case of the "C" type additional boiler-power is provided.

To meet the urgent need for more oil carriers an important alteration was made later in the construction of a number of the "A" and "B" type vessels, through which, if the necessity arose, they could be completed as oilers.

In addition, heavy oil carriers of 8,000 tons capacity, known as the "Z" type, are building. The overall dimensions of the "Z" vessels are the same as the "A" and "B"; the same standard type of engines are used as in the "A," "B" and "E" vessels.

All the types mentioned, except the "Z" oiler, were decided upon the designs prepared, and details arranged while the Merchant Shipbuilding Advisory Committee was still meeting at the Ministry of Shipping, and other types were projected.

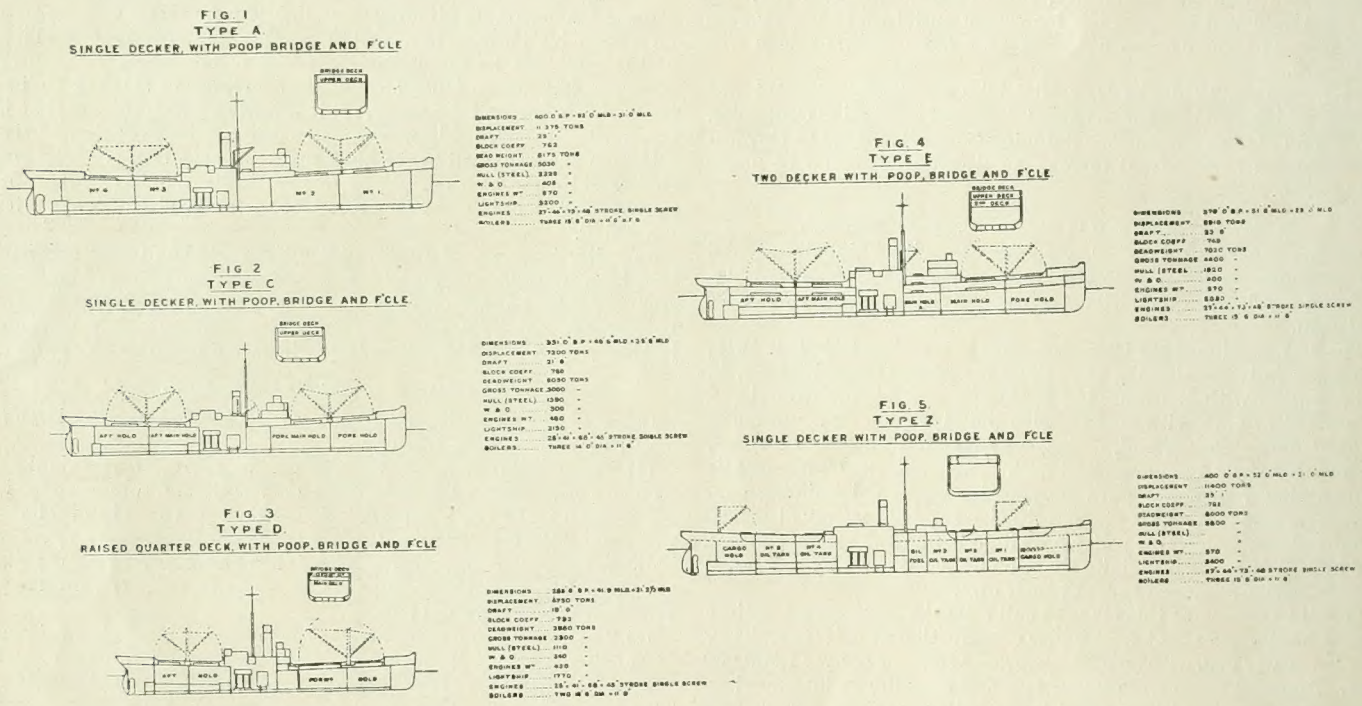
In designing the standard ships a point kept in view was the necessity for producing as quickly as possible plain cargo boats of the maximum carrying capacities with the least expenditure of material and labour, and of sizes most suitable to the majority of building berths and shipping conditions, &c. I feel that it is necessary to emphasise this statement because, obviously, the Government standard ships were designed to meet urgent war conditions. Whilst they might have a bearing on future standardisation, the question has not been dealt with from a peace standpoint.

The detailed design of each type in the first place was entrusted to a builder conversant with the class of vessel required and whose duty it was to carry out the work already mentioned. The engines were dealt with in a somewhat similar manner, except that one Scotch and one English engineer used to the class of work collaborated on the one design and its details—these and the design of the ship afterwards meeting with the full assent of the Committee. It was arranged that the Classification Societies should concur in the various scantlings, and undertake, on behalf of the Ministry of Shipping, the entire supervision of the vessels during construction. Two surveyors of Lloyd's Register who had been associated with the Ministry of Munitions in the production of steel were assigned the duty of allocating the orders for steel material to the steel-works and of arranging for its distribution to the builders in conjunction with the Government officials as required.

To facilitate the loading and discharging of cargoes large hatchways were arranged with an ample provision of derricks and winches. In the same connection the pillars were specially arranged as mentioned in Appendix I. (page 341). Further points of detail are discussed in Appendix I. for the hull, and in Appendix II. (page 342) for the machinery.

General considerations.—As experience was gained with vessels already at sea which had received damage by mine or torpedo, it was only to be expected that modifications would be suggested. For this reason, certain alterations were effected in the early standard ships after the plans were prepared. These were principally made on the advice of the anti-submarine authorities; but one other particular alteration is worthy of mention, in that greater safety and comfort is given to the crew by quartering them in the poop rather than in the forecastle, as was the usual practice before the war.

It will be remembered that the Council of the Institution formed a Committee last year to consider the question of the effect of mine



Figs. 1-5. Outline Profiles and Dimensions of Standard Ships.

and torpedo explosions on the structure of merchant ships. The majority of the findings of this Committee were embodied in the standard ships.

Certain precautions were taken to render the visibility of the standard ships as small as possible. The derricks and derrick posts were made to hinge down, and there is only one mast for carrying the wireless aerials. This latter is partly telescopic, and can be let down to the same level as the top of the funnel. The funnel is also made lower than usual. Ordinary deck-houses were fitted, and these, in conjunction with other outstanding features of the ship, can be masked by those on board when desired by the use of arrangements provided. The bulkheads of the standard ships are discussed in Appendix I.

In May, 1917, the Department of the Controller of the Navy was formed, and the work hitherto done by the Ministry of Shipping in connection with merchant shipbuilding was transferred to the new Department. The Merchant Shipbuilding Advisory Committee was also transferred, but shortly after this, for reasons which need not be stated here, the Committee resigned and the Controller of the Navy immediately formed a Shipbuilding Council to assist him in regard to all matters respecting shipbuilding, both merchant and warship building and repairing. The members of the old Advisory Committee became members of this Council. Further types of standard ships have been evolved recently.

To introduce any general system of standardisation of ships would have been difficult in normal times, it is only to be expected that it has proved to be so even in the midst of the greatest war in history. On the other hand, the need, having arisen so acutely, called for the attempt to be made. That criticism has arisen as to the Shipping Controller's policy, and the Advisory Committee's action was only to be expected when one considers the eminent ship designers and shipowners who have special ideas and interests in the design of some ships already built, and the many ideas that have at one time or the other been proposed. That good results have, however, been attained will, I have no doubt, be generally conceded, and the appointment of a Committee to consider the general standardisation of marine engines is a sign that we may expect standardisation to play a definite part in the future. In post-war work we shall have to consider everything making for cheapness and rapidity of production, and standardisation will not be the least among such considerations.

Appendix I.—Hull Details.

In all the vessels the longitudinal and transverse scantlings have been designed generally to comply with the standard of strength recommended by the Load Line Committee.

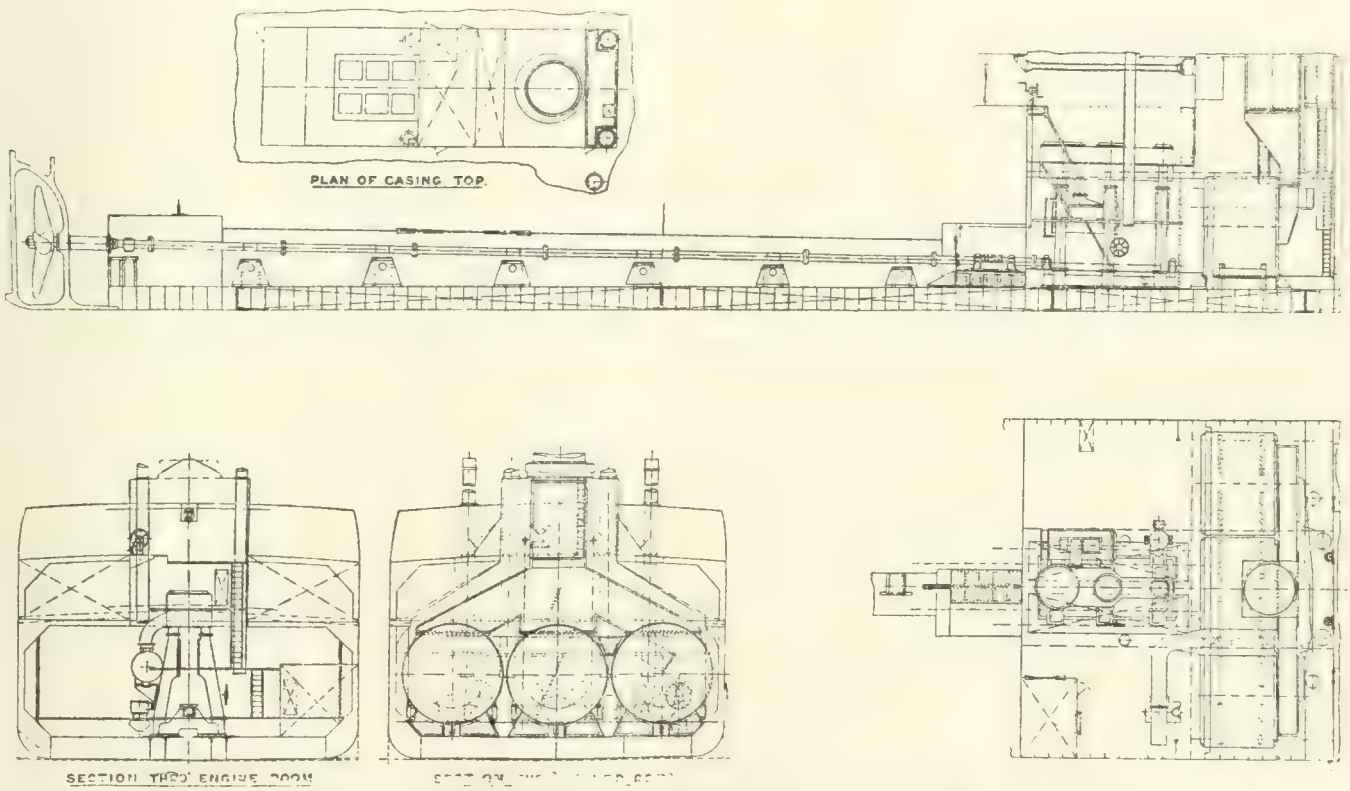
With a view to obtaining simplicity of construction, special consideration was given to the arrangement of the details of the structure, and it was decided to omit the ceiling on the tank top and the stringer on the ship's side, to fit only one keelson on each side in the double bottom, and to have large single angles at the upper and lower edges of the centre girder, suitable structural compensation or arrangements of equivalent strength being fitted in each case. The open bottom method of construction with solid floors on every third frame was adopted in the holds and boiler space, except in types "C" and "D," where, on account of the probability of these vessels being engaged in carrying ore and coal cargoes, solid floors are fitted on every frame throughout.

To reduce labour and avoid the necessity of bending the main frame, brackets of extra depth are fitted on the tank margin and no tumble home was given to the frames at the top sides. Only a centre row of pillars, reeled for shifting boards, was fitted (except for hatch side pillars in types "B" and "E"), and advantage was taken in several instances of the relative position of the hatchways and watertight bulkheads to support the deck by large brackets attached to the bulkheads, the holds being thus as free as possible from obstructions of any kind. To compensate for the absence of pillars at the sides of the hatchways, an arrangement of reinforced hatch-end beams and side coamings was adopted, the latter being also incorporated in the longitudinal strength of the ship in the way of the hatchways nearest amidships. In types "B" and "E," on account of the excessive depth required in the reinforced hatchways, side coamings and end beams at the second deck, when centre pillars only were fitted, it was decided to fit a pillar under each hatchway side coaming at the middle of the length of the hatch.

The officers and engineers, in accordance with the most recent practice, are berthed together in a large house at the fore-end of the bridge deck.

Approximate flooding calculations were made for all types of the standard ships.

In vessels "A," "B" and "E," with the main bulkheads in the positions arranged by the builders, it was found that, by making the cross-bunker bulkhead watertight, the vessels would approximately



General Arrangement of Machinery of Standard Ships

comply with the "two-compartment" standard in way of the machinery space and cross bunker, and the "one-compartment" standard elsewhere. The position of the cross-bunker bulkhead was arranged in order to fulfil the above-mentioned conditions.

In vessel "C," in addition to the bunker bulkhead, an additional bulkhead was fitted in the after-hold, in order to comply with the same condition.

Among the detailed requirements carried out in these ships which meet the findings of the Committee appointed by this Institution to inquire into the effects of mine and torpedo explosions, might be mentioned the following: No watertight door is fitted between the engine-room and the shaft tunnel, an access trunk being provided from the upper deck to the forward end of the tunnel. In addition, where watertight doors are fitted, they can be worked from an upper-deck position. Each suction-pipe, where it enters the compartment from which it drains, is provided with a screw-down non-return valve worked from the bulkhead deck.

Appendix II.—Engine Details.

The details of the engine design are arranged so that the machinery is rather overdriven for war emergency measures; this policy was followed so that after the war the ships become fairly reasonable commercial propositions. For example, the "A" engine would in peace time probably run at about 80 per cent. of the power obtained from it at present.

As with the hull, all the designs, when settled as previously mentioned, with the exception of the auxiliary machines, were prepared by one firm and issued to the various machinery contractors complete, together with full detail specifications of all the raw material orders and the finished items which it was arranged to obtain from sub-contractors. The drawings and information issued contained quite an unusual amount of detail, so that firms not familiar with such work would have no difficulty in carrying it out.

The main engine design does not present any new features. There are, however, some outstanding details. The front columns which carry the astern piston-rod guides have been utilised as engine oil-tanks. The moving parts of the engine are of the simplest type, and every attention has been paid to facility for overhaul.

The line shafting is all in interchangeable lengths.

The reversing gear is of the all-round type, and a turning engine and gear is fitted at the after coupling.

Ease of machining and assembling has been provided for in the arrangement and in the details, the piston type of valve for the medium pressure cylinder, for example, being adopted chiefly on that account. The centrifugal circulating pump is mounted with its engine on the main engine bed-plate, so that it can be fitted complete with its pipes and connections in the erecting shop.

Reference has been made in the paper to the advantages derivable from interchangeability, and examples of it have actually occurred. One firm, on discovering a defective sole-plate casting, had it replaced at once by a similar casting from another firm who did not require it at the time; this avoided a delay of several weeks in the erection of the engines. In another case a replaced main steam-pipe branch-piece was immediately dispatched to a vessel ready for her trial trip, the original one having shown leakage on the first steaming of the engine. Sub-contractors in particular were benefited by the multiple work, as they were enabled to proceed with a large number of each article instead of finding differences in small points of design as invariably occurs when the designs are prepared by independent firms or individuals.

The principle of repetition in design was embodied everywhere. Small castings were ordered in multiple.

Apart from the advantage to the sub-contractors in carrying out repeat work, small items in the engine-room which could be manufactured to better advantage by specialists rather than by large firms were ordered in large numbers for all the firms involved. This would not have been possible had they been different for each vessel. The orders for items such as auxiliary machinery, valves, valve-boxes, branch-pieces, cast and wrought-iron pipes, and so on, were issued in multiple from a single source by firms specialising in this work. For example, the main steam-pipes were finished complete by tube-makers, the drawings having been so designed that the unavoidable inaccuracies in fitting boilers and engines in place could be taken up at the joints, thus overcoming the delay which otherwise invariably occurs when pipes have to be made to fit after everything else is in position.

The auxiliary machinery was arranged so as to give the least work in completing the vessel after it was launched, the various connecting-pipes being of the simplest form while providing all the usual conveniences for working.

The feed-filter and feed-heater were embodied in a compact form in the engine hot-well, the feed-filter being easy of access. The winches exhaust to a winch-condenser in the engine-room, the size of which is ample to deal adequately with the winches when they are being used for a rapid discharge of cargo. The general service donkey and harbour-feed donkey are duplicates, and are capable of feeding the boilers in port or at sea.

The use of copper piping was avoided as much as possible, and wrought iron was largely used in consequence, except for very small pipes. The result is that the weight of copper piping is less than one-sixth the usual amount in this class of vessel.

The boilers have been designed in accordance with well-established practice, and there is ample room allowed for cleaning purposes and for overhauling. Howden's forced draught is fitted in all cases.

PROBLEMS OF THE FUTURE IN THE DESIGN AND CONSTRUCTION OF MERCHANT SHIPS.*

By W. S. Abell, M.Eng.

Research in naval architecture as well as in all branches of engineering received much attention in pre-war days, and the necessity of encouraging investigations in all directions was beginning to be realised by the commercial world when war broke out. Competition had resulted in a close study of shipbuilding methods and processes, and that as far as the production of ships *qua* ships was concerned, the United Kingdom as a whole was capable of producing them in a most economical manner. Every effort appears to have been made to reduce the weight of material, and in some directions advances had been made in obtaining increased output of labour. The rules of the Registration Societies imposed a limit upon reduction of weight, and beyond this the only saving possible involved considerations of redistribution of structural material. In general such redistribution required increased labour for fashionment and erection, so that once more a balance was reached between what may be termed the demands on labour and the limitations of material. Although it is not suggested that further saving is impossible in respect of labour and material for ship construction of the future, yet it is particularly true that in pre-war days the only feature of importance which was closely and scientifically investigated was the question of the resistance and propulsion of ships as affected by the form of the vessel and by the performance of propellers.

It is imperatively necessary to enlarge the field of vision and research in order to include every phase of shipping, whether shipowning or ship production. In this matter of research much closer co-operation is required in the future between all branches of the industry, between the underwriter, the shipowner, the shipbuilder, and the marine engineer.

The most successful vessel is that which obtains the greatest power of transportation at minimum cost. Power of transportation may be defined as the quantity carried per unit of time. It is not sufficient for a vessel to carry a certain deadweight alone, but it is necessary that such deadweight be transported at a given speed, and that the relation of capacity to deadweight be such as to utilise the maximum draught which the dimensions and strength of the vessel permit.

The cost of the operation depends on:—(*a*) First cost; (*b*) maintenance; (*c*) seaworthiness and safety; (*d*) number and nature of crew; (*e*) fuel; (*f*) speed; and (*g*) time spent in port.

A.—Economy of Ship Operation.

Resistance of ships.—A large amount of data has been accumulated as the result of the form experiments made in various experimental tanks of this country. As a consequence, it is possible now to obtain a fairly close approximation to the plain form required for a given displacement, length and speed. Such results are of great value when used on a comparable form, but much work still remains to be done to complete the knowledge of the various corrections to be applied to the results of model experiments in order to obtain the data for the full-size vessels. There is no doubt that the resistance of the model as regards wave-making can be very accurately measured, and there is also very little doubt, if any, that the wave-making resistance of the full-size ship is accurately given by a scale correction of the model results.

It is to be observed, however, that in the large majority of merchant vessels the wave-making resistance is only some 20 per cent. of the total resistance, the remainder being due to skin friction and eddy-making. The frictional resistance requires to be estimated, and

* Abstract of a paper read at the Fifty-ninth Session of the Institution of Naval Architects on March 21. The discussion will be found on page 360.

here the basis of calculation is determined by experiments which have been made mainly on planks of small area and of lengths not exceeding 50 ft. The extension of such results to the ordinary merchant ship of, say, 400 ft. in length, and particularly to the large fast liner of, say, 800 ft. in length, is largely a matter of conjecture. Moreover, the nature of the surface has a large effect on the calculation. The general trend of such results as exist indicate that with a paint or varnish surface the frictional resistance per unit area at given speed diminishes with the length.

If the estimates of power are to be more closely approximated to in future, it is essential that some large-scale experiments on frictional resistance of full-size vessels should be carried out in order to obtain some basis to correct the frictional calculations obtained from model experiments.

Power required at sea.—The usual tank experiments provide an estimate for power in terms of speed, under what is termed "still-water conditions." It is not an easy task to obtain even an approximation to the loss of speed brought about in rough weather, and it is still largely a matter of opinion whether the form which is most suitable for speed in smooth water is the best form for speed keeping under average conditions. In order to obtain data, it would be necessary to run model experiments, to have a fully loaded measured mile trial of the vessel, and to analyse to some extent (making allowance for weather conditions) the performances of vessels on service. There do not appear to be great difficulties in the way of such procedure, provided shipowners will co-operate on a generous scale.

Resistance of appendages.—Model experiments are determined for a "naked" ship; that is, certain appendages are omitted, such as shaft brackets, shaft bossings, rudder posts and rudders, and bilge keels. There is no doubt, however, that the resistance of these appendages is of importance, not only as regards form, but also as regards performance of propellers. It follows, therefore, that experiments on a large scale would be of assistance, and might conceivably form part of the proposed friction experiments on a full-size vessel.

Screw propellers.—Although much attention has been given in many directions to model experiments with screw propellers, yet in view of the enormous complexity surrounding the problem, it is still possible for an expert to design a bad propeller.

The advantage of some methodical series of large scale experiments co-ordinated with complementary experiments in a tank will be of service, and will further help to establish a proper relation between the performance of a model and the actual vessel.

It will be helpful if shipowners would, as occasion offers, carry out measured mile trials of fully-loaded vessels, and have the results carefully analysed. When the trial data were available, the information could be supplemented by careful logs of sea performance under different weather conditions.

It is now opportune to discuss certain points for research, which, although having features in common, yet perhaps may be differentiated into two main classes, viz., factors of design and questions underlying economy of production of vessels.

Factors of design might include questions relating to:—(*a*) Seaworthiness; (*b*) safety, involving—(1) stability, (2) subdivision; (*c*) time spent in port; and (*d*) relation of deadweight to capacity.

Seaworthiness.—Questions of seaworthiness and sea-kindliness have been discussed on many occasions with advantage. The factors which tend to facilitate good time-keeping are largely height of platform forward, coupled with sufficient reserve of buoyancy.

The proper relation of breadth of vessel to depth to the upper or bridge deck is also of more importance than is commonly accepted. It is true that a moderate breadth favours easy rolling, but, on the other hand, it may prevent reasonable economy in working the vessel in average trades by requiring an undue amount of ballast. There was a tendency just previous to the war to revert to narrow and deep ships, such as were shown to be dangerous some thirty years ago. Owing to the adoption of the shelter-deck type and the subsequent addition thereto—found necessary by sea experience—of forecastle, bridge, and poop, the narrow and deep type was being slowly approached.

Recent investigations made by the Load-line Committee have shown that the ordinary three-island vessel with long bridge and two short wells with good proportions and with the ordinary freeboard is probably the most seaworthy type of those at present in vogue.

Stability.—Stability at sea, although perhaps the want of it is fortunately not often experienced, is of great importance. Present knowledge of the subject is confined to statical calculations; estimates of the arm of righting couple and the angle of vanishing stability are seldom made.

The question of initial stability and the determination of the metacentric height are generally not considered, or at best only evaluated in an empirical manner, and very few attempts have been made to deal with the general question of the stability of a vessel in a seaway in terms of dimensions.

A ship among waves and exposed to wind pressure is subject to displacement from the position of equilibrium by reason of the energy transmitted from the wave and wind systems. This energy is absorbed in two directions: (1) By the resistance of the form and keels to rolling, and (2) by the righting couple due to the inclination of the vessel. It is possible to calculate approximately, or to deduce from model experiments the rolling resistance in still water, and it should also not be difficult to approximate experimentally to the same factor when a model is exposed to a regular system of waves. The righting couple is calculable both for still water and approximately so for a regular system of waves. Consequently it seems possible to deduce from experience the curve of stability which should be provided for a vessel of given dimensions when exposed to heavy weather. Expressed generally, the quantity to be determined is the work required to capsize the vessel, and this quantity is the difference between the energy transmitted by the wave and wind systems and the resistance to rolling among waves. Detailed reports of the experience of vessels in bad weather would give the basis of such determinations.

Watertight subdivision.—Experience of submarine warfare appears to show that further consideration is required, more particularly in regard to the relation between nature and extent of damage and amount of subdivision.

It certainly appears desirable to attempt to find a modified system of rules which would be as easy of application as possible.

Time spent in port.—The great majority of vessels spend perhaps half their existence in port. Even in long voyages it is not uncommon to find that only 60 per cent. of the time is passed at sea. This factor is one of supreme importance in design and has not received the attention it has deserved. There must be an economic relation between the length, breadth, and depth of holds. A narrow, deep hold, except perhaps for bulk of discharge, must obviously be more difficult to work than a broad and shallow space.

The relation of deadweight to cubic capacity.—It is admittedly a difficult matter to determine the proper relation between the deadweight carried and the space available for stowage in the case of the cargo tramp. But as owners work more or less through fixed agencies it will happen that after a time conditions somewhat approximate to stability, and within limits a ratio can and should be obtained. It is extremely desirable that a vessel should carry as much weight as possible, but the determining factor in the tonnage of this country in the past has been the imports of raw material, which are relatively bulky. Consequently on the supposition that pre-war conditions are maintained—and they must be, since the sea power of this country is largely determined by a thriving industry in the United Kingdom—the aim must be capacity rather than deadweight. The proper relation for general purposes of these two quantities is therefore an important question for broad research. With given dimensions, capacity can only be gained by reducing deadweight and by reducing the light weight of both hull and machinery. The importance of weight of the light ship becomes greater when economic conditions become more stringent.

B.—Economy of Ship Production.

The aim of the shipbuilder is to produce at the lowest possible first cost, subject to a proper provision for wear and tear, an instrument of transportation which will convey a given quantity of goods at a desired speed. It is therefore of importance to study two broad factors—economy of material and economy of labour.

C.—Economy in Material.

Distribution of material.—It has been rather unfortunate that in past times it has been conventionally agreed that certain parts of the structure are only called upon to meet strains in one direction—that is, the straining forces have been analysed in respect of either the longitudinal, transverse, or local senses. In general, however, some parts may be called upon to bear stresses arising from both longitudinal and transverse straining actions as well as local conditions. It is largely a matter of conjecture what provision

is necessary to bear the combined results: it is not in general true to infer that the material must be sufficient on the one hand to withstand either the maximum strain in any sense, or, on the other hand, to assume that the arithmetical sum of the strains must be met. In considering redistribution of material, therefore, it will be desirable, as far as practicable, to depart from this present convention and to estimate the interaction of adjoining parts of the structure under combined stress. A research into the possibilities of maximum amount of material for longitudinal distribution and a minimum amount for transverse requirements is eminently desirable. But coupled herewith must be considered the alterations in works processes which are likely to be required.

Local strains are still more difficult to evaluate, and can only generally be met by a close study of experience at sea. Merchant vessels are particularly prone to sea damage at the forward end, both in the side plating and in the double bottom. The heavy and unusual duty performed by vessels in war-time has accentuated the difficulties ordinarily experienced.

Again, although the fibre stress per unit area which material will stand is ordinarily known, or rather comparatively determinable, yet, under compression, failure may and commonly does occur owing to insufficient local support. There is therefore to be sought a relation for spacing supporting members in terms of the thickness of material, such as a deck, which has to be supported against compression.

This discussion on local failure brings up the question of secondary bracing. Certain girders and stringers require brackets in order to prevent collapse from oblique loading; it is not an easy matter for any form of calculation, but a close study of actual experience should produce rules for general guidance.

Construction of double bottom.—Even the most enlightened naval architects appear to have only hazy ideas concerning the structural work performed by the complicated double bottom, which is now a common feature in merchant ships. The more general practice is to dispose the internal framing in the transverse direction, retaining a very small amount of longitudinal material mainly for local support. These longitudinal intercostal members also fulfil some function as secondary bracing, but the nature of the work performed is very obscure. It is, of course, true that facility of erection has favoured transverse framing; but here, again, if economy of weight is required, search must be made for a distribution which is more in the longitudinal sense than the present practice. Some well-known efforts have already been made towards this aim, but the final solution has yet to be sought.

The double bottom of a merchant vessel suffers much from inaccessibility, and any development which would mitigate this important disadvantage would be welcome so long as the structure were able to perform its work efficiently.

Stiffness of structure.—Although stiffness and deflection are closely studied in land structures, yet as far as ships are concerned insufficient attention has been paid to this important matter. It is certainly true that the Registration Societies provide some safeguard against undue deflection, which limitation is expressed very generally as a proportion between length and depth of structure. It is extremely desirable for economy of material to extend our knowledge of this branch of study in order to obtain the best disposition of material. Attention might also be called to the necessity of giving more consideration to the question of stiffness of transverse and longitudinal framing.

Efficiency of connections.—This question is of the highest importance, since it is of little use to provide structural material and then court failure in the method of attachment. The experience of many years certainly indicates that, generally speaking, the present systems of riveted connections perform their work well in regard to main structural stresses, and in cases of local stresses the alterations dictated by experience have fairly well met the needs. The growth in size of vessels has resulted in increased size of rivets with a consequent need for the greater use of power tools. It has, however, become desirable to ascertain whether, under modern conditions, it would not be possible to make alterations in methods of connection and reduction in sizes of rivets without sacrifice of efficiency.

D.—Economy of Labour.

Although post-graduate research scholarships in naval architecture have been in operation for some time, and although the attached conditions clearly contemplate that research students should investigate the development of the shipbuilding industry at home and abroad, yet so far this important purpose has not been realised.

Study of labour processes has already been somewhat widely undertaken in some branches of the engineering industry, but this study has been largely confined to the mechanical side, and it would appear that insufficient attention has been given hitherto to the question of shipbuilding.

The question appears to be dominated by two main considerations:—(*a*) Increased output of labour, and (*b*) disposition of material to ensure a minimum amount of labour.

Increased output of labour involves the provision and proper utilisation of labour-saving devices, but here it must be remembered that saving is not effected unless the time factor for an operation is properly related to the time factors of the other processes. For example, it would be useless to speed up the preparation of plates unless the output of the supporting framing were adjusted equally. Consequently, although one particular class of employee would be producing at a higher rate, the periods of delay in other processes would reduce and prevent any ultimate gain.

The need for the study of the problem as a whole, and not for particular items, is at once evident, for otherwise labour must raise objections to an introduction which would not ensure continuity of employment. On the other hand, the workman must recognise that he is unable to increase his earnings without a corresponding co-operative effort on the part of the employer to regulate the other branches of the establishment.

Work preparatory to construction.—There appears to be room for improvement in drawing-office and mould-loft practices which ought to bear a close relation to the labour processes required for actual construction. Study of form and disposition of plating would tend to reduce scrap and to avoid much shaping of plates. It would be a great advantage if plates could be made rectangular in shape for a good portion of the length and the material then be ready for use as delivered from the steel works. It is considered that even towards the ends it is possible to introduce more parallel plating than is commonly done. Further, the use of templates should be reduced to narrow limits either when provided from the mould loft or when obtained from the ship during erection.

Fashioning of material.—The increased use of parallel plates already mentioned will avoid shearing if the steel works shape the plate as nearly as possible to the dimensions. The trimming of butts and edges might conveniently be studied with a view to save labour. Recent developments in the use of the multiple punch for ship work have shown that this system can be well adapted, and that to a large extent for shell and deck plating.

Smiths' work, which is both costly and difficult, might be increasingly avoided by arranging for repetition work as much as possible, and fashioning these parts in numbers by hydraulic presses.

The avoidance of templating at the ship must lead to increased output, and here again arrangements for repetition work would be of great advantage.

Erection, including connections.—This question involves careful consideration of berth appliances. The sizes and weights of the pieces to be handled are of importance, and such pieces should be as large as conveniently possible to reduce labour of connection. The structural details should be so arranged that the parts are conveniently attached, and can be temporarily placed in position without much adjustment and without distorting appreciably under their own weight. The use of power riveting tools can, in the opinion of most builders, be largely extended, more particularly perhaps in the direction of pneumatic appliances. In this case, however, great care is required in the periodical inspection of the tools and of the plant in order to obtain a sufficient and constant supply of power at the ship, and in order to ensure that the riveting machines are giving out the proper power in relation to the consumption of air. It appears necessary to devise certain simple tests and gauges which shall indicate these requirements. The extension of hydraulic riveting is of some importance, but hydraulic power is not so conveniently applied, and is expensive in operation.

There are also indications of a future possibility that some forms of electric welding may be adapted for structural work.

Completion of vessels.—In the later stages of construction it is necessary to devote considerable attention to the fitting of the equipment, the navigation instruments, and the multitudinous items necessary to the proper working of the vessel. It would appear to be to the advantage of the whole industry to take steps to secure bulk manufacture of these numerous small details by setting up standard forms.

It also appears desirable that steering gears and engines should conform to certain standard specifications, and that boats and davits should be of interchangeable patterns.

THE MOST SUITABLE SIZES AND SPEEDS FOR GENERAL CARGO STEAMERS.*

By John Anderson.

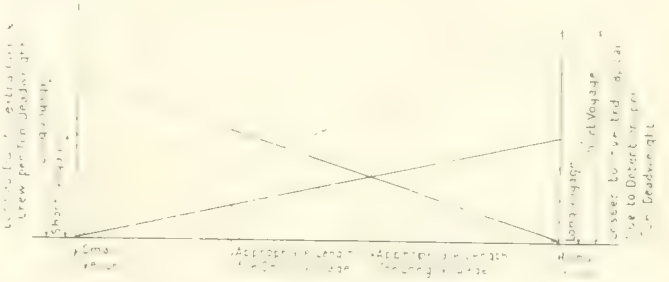
With the object of combining the interests of the designer, the owner, and the builder, and of eliminating a number of difficult corrections, the writer has endeavoured to formulate a method by which the most economical dimensions can be arrived at, for any length of voyage, condition of loading, or speed.

The efficient part of a vessel's working life is when transporting cargo from one port to another, and the period spent in loading and discharging, although necessary, can only be considered as lost time. The efficiency of a vessel transporting cargo at a minimum speed (which will be defined later) can therefore be expressed as—

$$(E) = \frac{T - t}{T}$$

where T is a convenient total period of time, and t is the proportion of T which is required for loading, discharging, docking, &c.

Items 1 and 2 represent savings in cost of transportation, whereas item 5 represents loss of invested capital, and it follows that the most suitable size of vessel is that which gives the best economic adjustment between these opposing factors. This can be illustrated diagrammatically, thus :—



A relatively long voyage or rapid system of loading and discharging will increase the value of (E), while an increase in dimensions or in

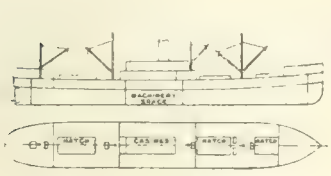


Fig. 1.
Dimensions 250' × 37' × 18'–6'

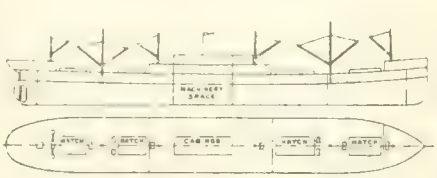


Fig. 2.
Dimensions 330' × 45' × 24'–6'

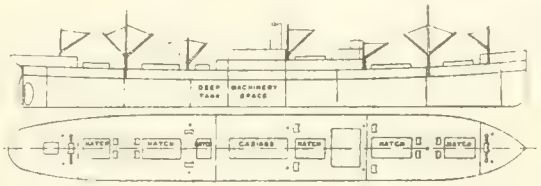


Fig. 3.
Dimensions 410' × 53' × 30'–3'

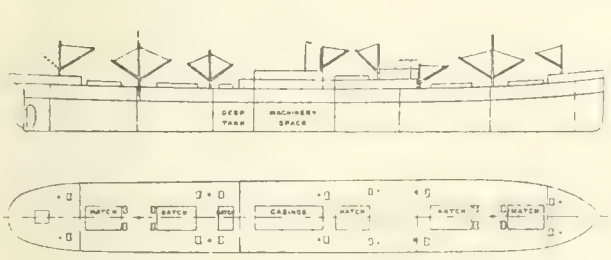


Fig. 4.
Dimensions 490' × 61' × 36' 4'

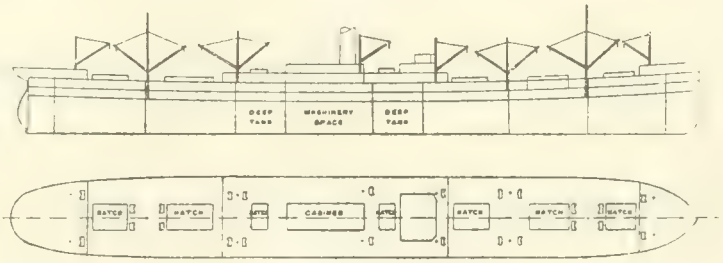


Fig. 5.
Dimensions 570' × 69' × 42'–3'

Figs. 1–5. Designs of Ships of varying Lengths for calculating possible Working Values.

There are many inducements towards building large vessels, the most important of which are—

(1) Reduced initial cost in relation to the deadweight.

(2) Reduced horse-power, crew, and amount of coal required in relation to the deadweight.

(3) Greater seaworthiness.

The problem cannot be considered sectionally, however, and an owner is sometimes prevented from utilising these advantages fully on account of—

(4) The length of voyage.

(5) The increased length of time required to load and discharge a large ship (which time might for convenience be termed "Detention").

(6) The unsuitability of certain harbours, loading berths, and dry docks.

(7) Greater loss in case of mishap or disaster.

The lost time suggested under item 5 is of considerable magnitude, as the number of hatches or derrick systems which can be arranged in vessels of equal proportions will vary as $\sqrt[3]{\text{deadweight}}$, or, with holds of equal length, the work to be done at each hatch will vary as B, D, H, where B and D are the breadth and depth respectively. H (see Fig. 6, page 346) is the average distance through which the cargo has to be transported.

It will be seen from this and the figures given in Table I (page 347) that the average work to be done at each hatch in a 250-ft. vessel is about 16,000 ft.-tons as compared with 250,000 ft.-tons in a 570-ft. ship.

increase of speed for a fixed length of voyage and fixed derrick speed will reduce it, and from these facts it may be presumed that length (or dimensions) may vary in some proportion to (E).

Method of calculating results.—The problem is to find the dimensions which will give the best compromise between items 1 and 2 and item 5, and in order to obtain information covering a wide field, it was decided to calculate the possible working values of 25 vessels, for voyages of 1,000, 4,000 and 8,000 nautical miles, for two speeds of loading and discharging, and for service speeds of 8, 9½, 11, 12½ and 14 knots.

The designs were divided into five groups, each having lengths of 250 ft., 330 ft., 410 ft., 490 ft., and 570 ft., and each group was subdivided to give the speeds already mentioned.

The arrangement of each size of vessel is illustrated on Figs. 1 to 5, and the length of machinery space indicated is for a speed of 11 knots. In the vessels above this speed it will be increased in length, but it was assumed that this increase would not affect the number of hatches or derrick systems.

Each vessel is of the poop, bridge, and forecastle type, these erections extending over about 50 per cent. of the vessel's length. The ratio of length to depth is 13½ times, this being the maximum which Lloyd's will allow with normal scantlings, and it may also be said that this ratio gives the maximum length for derrick arrangements and minimum draught in relation to the deadweight. The breadth has in each case been made equal to $\frac{\text{length}}{10} + 12$ ft.

The number of winches and derrick systems were arranged to give the maximum number of receiving stations on the quay side, and it was assumed in the calculations that the derricks would be worked

* Abstract of a paper read at the Fifty-ninth Session of the Institution of Naval Architects, March 20. The discussion will be found on page 357.

on the "yardarm" system if two winches were fitted abreast, and by "swinging" if only single winches were arranged.

It has been assumed that the bulkheads are placed so that the work to be done will be equally divided between the winches or derrick systems.

The time required in port was estimated from the derrick capacity, and to obtain a basis for this it was decided to assume that the maximum amount which could be handled per day of 10 hours in the 410-ft. vessels would be 360 tons per "yardarm" system and 276 tons per "swinging" derrick. Proportionate amounts were obtained for the other sizes of vessels by assuming that the time required for hooking and slinging the cargo would be constant, and that the time required for discharging would be proportional to the distance H. On this assumption the following values were obtained:—

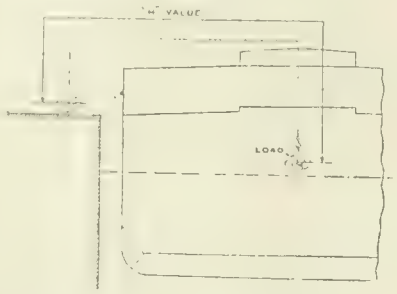


FIG. 6.

Diagram showing method of calculating "H" value.

Table I indicates the method adopted for calculating the working values of the vessels, and the figures shown refer to the 11-knot speed for each size of vessel. The items are generally self-explanatory, but reference may be made to the following:—

(*a*) The draughts are based on present regulations of the Board of Trade, and the block coefficients have been made appropriate to the service speeds. The dictum of the experienced shipowner has been followed with regard to the block coefficient, viz., that it should not exceed ·77 whatever the speed may be.

(*b*) The "weight of vessel" used is that of a bare cargo hull to Lloyd's rules, with engines of triple-expansion type, these driving twin screws where the service horse-power exceeds 5,200.

(*c*) An addition of 12 per cent. has been made to the calculated time in port to allow for stoppages during holidays, week-ends, &c., and an allowance has been made for coaling during the 8,000-mile voyages. In addition to these, 14, 18, 22, 26 and 30 days respectively have been allowed for each size of vessel per annum for repairs and other delays, and these have been assessed at their rates per voyage. It has been assumed that coaling will be effected while the cargo is being worked.

(*d*) The coal per voyage has been estimated from a curve, the ordinates of which are 2 lb. per horse-power per hour at 800 h.p., 1·7 lb. at 2,200 h.p., and 1·6 lb. where the horse-power is 4,000 or more. The coal for port use has been assumed as proportional to the weight of cargo and the distance H. It was also assumed that vessels making an 8,000-mile voyage would be rebunkered at a port intermediate between the terminal ports.

(*e*) The net tonnage is that obtainable by Board of Trade regulations, and includes the present allowances for propelling space.

(*f*) The money values are not the present ones, but as they are comparatively correct between each size and speed of ship and between initial cost of vessel and cost of transportation, they have no influence on the results of the relative efficiencies. Notwithstanding this statement, however, the effect of increased labour and other rates has been investigated, and the results are given later.

(*g*) Line No. 20 in Table I gives the "tons carried" in relation to the initial cost of vessel, and line 30 gives the estimated freight rates. Cross curves of these have been drawn for each stated condition, and Figs. 7 to 9 illustrate these curves for three of the conditions.

Results.—It will be seen from these curves that the ratio of "tons carried" defines the appropriate length most prominently, but, as cost of coal, l bour, &c., must also be considered, it was thought necessary to fix the appropriate length line indicated, by interpolation, between the highest part of the "tons carried" curve and the lowest part of the "freight rate" curve.

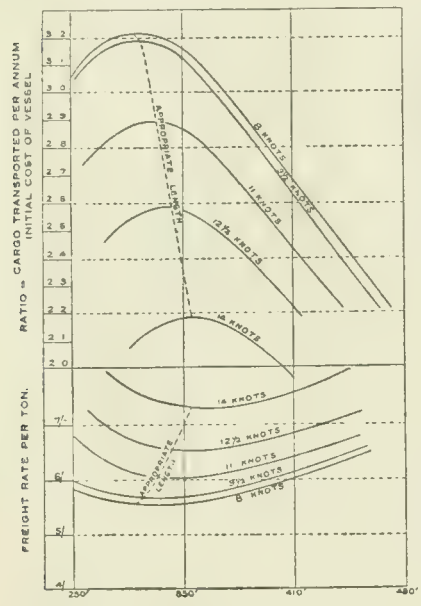


FIG. 7.

SCALE OF LENGTH

45% DERRICK CAPACITY

1000 NAUTICAL MILES.

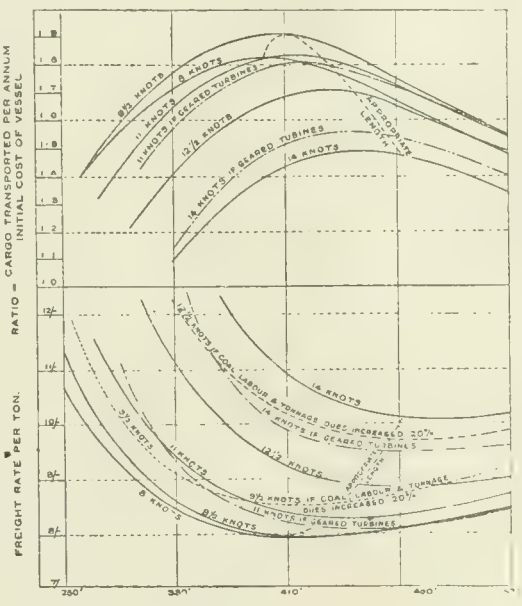


FIG. 8.

SCALE OF LENGTH

MAXIMUM DERRICK CAPACITY

4000 NAUTICAL MILES

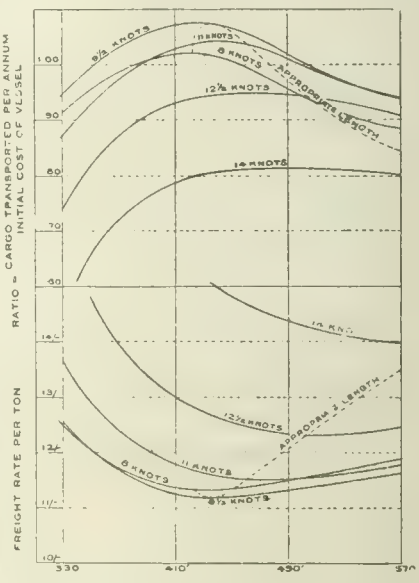


FIG. 9.

SCALE OF LENGTH

MAXIMUM DERRICK CAPACITY

8000 NAUTICAL MILES.

Length of vessel.	Working rate per day of 10 hours. Yardarm system.	Swinging system.
250 ft.	445 tons	360 tons
330 ft.	394 ,,	318 ,,
410 ft.	360 ,,	276 ,,
490 ft.	338 ,,	250 ,,
570 ft.	318 ,,	229 ,,

The writer is aware that these values are higher than is found in present-day practice, but he purposely kept them high to obtain a wide field and to cover possible future improvements in methods. In order to obtain the lower limit for working rates, alternative calculations were prepared on the assumption that the derricks would be worked at 45 per cent. of the rates given.

It should be pointed out that as these assumptions are made only for the purpose of calculating (E) values in relation to the different lengths of voyage, the quantitative working values are not of importance, and the only object in setting off the relative amounts for each size of ship is to show how the larger vessel may be penalised in discharging speed.

To complete the main investigation, the appropriate lengths of each condition and distance have been plotted on a base efficiency (E), and these results are indicated on Fig. 10 (page 348).

The spots on this figure for the lengths appropriate to 8,000 miles and 45 per cent. derrick capacity are greater proportionately than those for 4,000 miles and maximum derrick capacity, the explanation of this difference being that the vessels on the longer voyage have intermediate coaling stations. The difference due to this fact does not, however, affect the results to any appreciable extent.

the ballast run is estimated as an extended length of voyage, and not as lost time, in calculating the (E) value, a correct result will be obtained.

Fig. 11 gives the relative "tons carried" and "freight rate" in terms of speed for the appropriate lengths, and these have been plotted as a percentage of the best and lowest results. It will be seen that the most economical speeds are from 9 to 9½ knots, but it is understood that higher speeds are necessary when cargoes of a perishable nature are carried.

TABLE I.—*Estimated Qualities for a Voyage of 4,000 Nautical Miles and Maximum Derrick Capacity.*

Item No.	Particulars	Speed in Knots.				
1	Dimensions	250 × 35 × 18·6	360 × 47 × 24·6	440 × 57 × 31·5	500 × 64 × 36·4	570 × 68 × 42·37
2	Displacement Tons	3,031	6,525	11,520	18,360	27,330
3	Draught	16·7½	20·9½	27·4½	32·11	37·7
4	Block coefficient	·68	·74	·76	·77	·77
5	Service horse-power	1,248	1,935	2,540	3,230	4,080
6	Weight of vessel	1,152	1,934	3,260	5,234	7,515
7	Initial cost of vessel	£26,700	£44,700	£66,800	£104,900	£153,700
8	Net tonnage	700	1,660	3,210	5,400	9,780
9	Crew	24	33	46	56	65
10	No. of derrick systems Variable swinging	4	2	7	11	12
		4	6	2		
11	Gross deadweight	1,879	4,860	8,260	13,126	19,815
12	Coal consumed per voyage Tons	389	706	754	978	1,257
13	Stores, fresh water and feed water ,,	61	90	121	161	196
14	Net cargo deadweight	1,388	3,885	7,356	11,987	18,362
15	Days on run	15·15	15·15	15·15	15·15	15·15
16	Days in port	2·37	4·10	6·75	8·95	13·09
17	No. of runs per annum	20·83	18·92	16·65	15·15	12·91
18	Total cargo per annum Tons	28,910	73,500	122,500	181,600	237,000
19	Total coal per annum	8,102	10,710	12,550	14,820	16,228
20	Cargo transported per annum / Initial cost of vessel	1·082	1·643	1·834	1·731	1·542
21	*Cost of operation per annum*					
22	Brokerage and management, 9d. per ton	£ 1,084	£ 2,757	£ 4,594	£ 6,810	£ 8,888
23	Loading and discharging, 1s. 6d. per ton	2,168	5,514	9,188	13,620	17,776
24	Coal, oil, &c., at 12s. per ton	4,861	6,426	7,530	8,892	9,737
25	Tonnage dues at 1s. 3d. per ton	913	1,965	3,345	5,120	7,904
26	Wages and provisions	2,017	2,772	3,865	4,705	5,460
27	Depreciation, insurance, repairs (one-seventh initial cost)	3,819	6,393	9,543	14,986	21,964
28	Total outlay	£14,862	£25,827	£38,065	£54,133	£71,729
29	Profit to give 20 per cent. on the initial cost	£5,346	£8,950	£13,360	£20,980	£30,730
30	Rate per ton to give 20 per cent. gross profit	14s.	9s. 5½d.	8s. 4½d.	8s. 3½d.	8s. 7½d.
31	Efficiency $\frac{T-t}{T}$ (E)	·860	·785	·692	·629	·536

Figs. 7 and 9 represent the extreme limits of efficiency for the calculated conditions, their relation being $\frac{8,000}{1,000} \times \frac{1}{·45} = 17·8$ times the loading speed, or length of voyage, and it is thought that from these and the curves on Fig. 10, lengths appropriate to best results for any known or average length of voyage, condition of loading or speed, can be obtained for vessels engaged in the carriage of cargo only and having no assistance from the revenue obtained by carriage of passengers.

To illustrate the effect of increased cost of coal, labour and tonnage dues over the originally calculated amounts, additional lines have been indicated on Fig. 8 to show the effect of increasing the cost of these items by 20 per cent., and it will be seen that although this would tend to increase the appropriate length, such increase would not be of great magnitude.

Some calculations have been made to find the effect of vessels making return voyages in ballast trim, and it has been found that if

It has not been found convenient to illustrate the curves for each calculated condition of loading, but Table II is given to show the effect of altered discharging speed on the "tons carried" and "freight rate."

TABLE II.—*To show the effect of Altered Derrick Speed on Freight Rate and Tons carried at the Appropriate Lengths.*

Condition.	Speed of vessel.	Derrick speed.	Freight rate. s.	d.	Tons carried.
1,000 nautical miles	9½ knots	Max. D.C.	4	9	4·89
	9½ ,,	45% ,,	5	8	3·19
,, ,,	14 ,,	Max. ,,	5	9	3·49
	14 ,,	45% ,,	7	3½	2·18
4,000 nautical miles	9½ knots	Max. D.C.	7	11½	1·91
	9½ ,,	45% ,,	9	2	1·50
,, ,,	14 ,,	Max. ,,	10	2	1·47
	14 ,,	45% ,,	12	7½	1·10
8,000 nautical miles	9½ knots	Max. D.C.	11	2	1·075
	9½ ,,	45% ,,	12	6	·916
,, ,,	14 ,,	Max. ,,	13	9	·82
	14 ,,	45 ,,	16	8	·687

Other types and proportions.—The appropriate lengths shown on Fig. 10 will be applicable to other types of cargo vessels, provided that in comparing the dimensions of one vessel with another the characteristics and proportions are similar.

Stowage capacity.—Stowage capacity will often influence a designer in arriving at the most suitable size of a vessel, and it is found that the stowage rate per ton of cargo for fixed speed is reduced as length

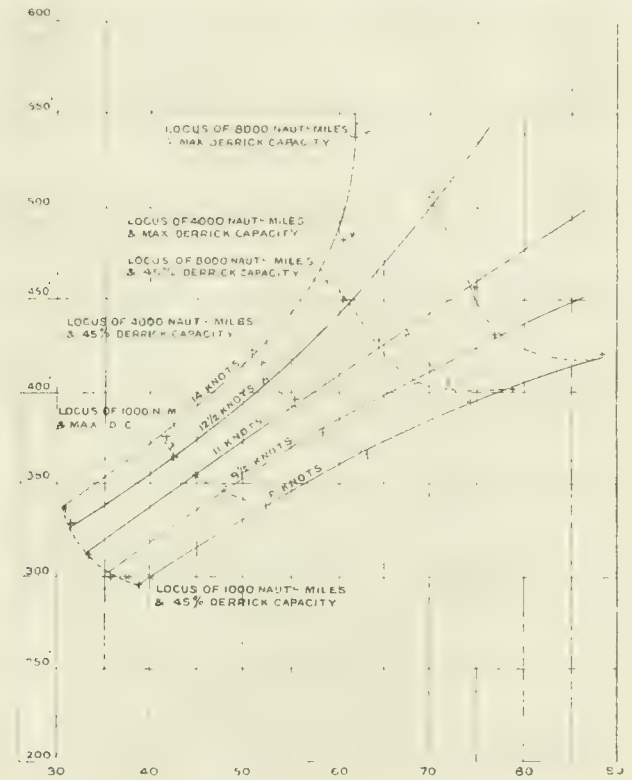


FIG. 10.

APPROPRIATE LENGTH IN TERMS OF EFFICIENCY.

is increased; it may, therefore, in some cases be found profitable to choose a slightly shorter vessel than the curves indicate.

Improved types of machinery.—The effect of geared turbine installations with double reduction gears has also been investigated from the particulars given on Fig. 12, and the results are plotted for speeds of 11 and 14 knots on Fig. 8. It appears that these improved propulsive elements, with reduced coal consumption would

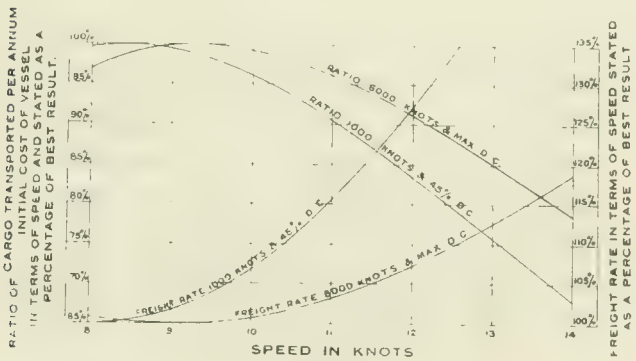

RATIO OF CARGO TRANSPORTED PER ANNUM IN TERMS OF SPEED AND STATED AS A PERCENTAGE OF BEST RESULT.
FREIGHT RATE IN TERMS OF SPEED STATED AS A PERCENTAGE OF BEST RESULT
RATIO 8000 KNOTS & MAX. D.C.
RATIO 1000 KNOTS & 45% D.C.
FREIGHT RATE 1000 KNOTS & 45% D.C.
FREIGHT RATE 8000 KNOTS & MAX. D.C.
SPEED IN KNOTS

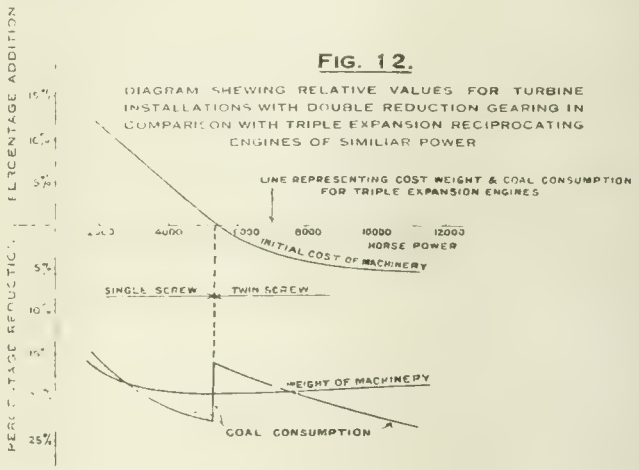
FIG. 11.

not appreciably alter the appropriate length of vessel. They affect the earning power considerably, however, and on account of the present relatively high initial cost of this type of engine for low powers, geared turbines are evidently unsuitable for speeds of less than about 10½ knots.

Conclusions.—It appears from these investigations and the results of actual ships tabulated hereafter that the most suitable length of a "tramp" trader would be between 380 and 400 ft. with a speed of 9 to 9½ knots. The maximum efficiency (E) of the most up-to-date cargo liner does not exceed ·60, which with a speed of 12½ knots would have a length of about 450 ft. and a corresponding maximum draught of about 28 ft. In view of this maximum draught, it appears to be an open question whether the proposed deepening of trade routes should be considered prior to legislation being completed for improvements in our harbours, such as increased berthing and loading facilities at quays, increased storage capacity, and the removal of many port restrictions which have caused detention to our ships in the past.

FIG. 12.

DIAGRAM SHEWING RELATIVE VALUES FOR TURBINE INSTALLATIONS WITH DOUBLE REDUCTION GEARING IN COMPARISON WITH TRIPLE EXPANSION RECIPROCATING ENGINES OF SIMILIAR POWER



The curves of gross deadweight given on Fig. 13 will be found useful for comparing one vessel with another.

The writer desires to thank the directors of Scotts' Shipbuilding & Engineering Company for their permission to publish these results. He also thanks the friends who have advised and assisted him in the development of these notes.

Appendix.

To show the possible use of, and the method of applying, the curves on Fig. 10, the following illustrations are given:—

No. 1.—A cargo tramp, 400 ft. in length, and having five hatches, each of which is worked by derricks at one end, has the following characteristics for the period under consideration:—

Load deadweight	8,000 tons.
Total steaming time	310 days.
Total loading and discharging time	255 ,,
Total time for coaling, repairs, &c.	30 ,,
Average service speed	10½ knots.

Is this the most economical length?

The total period T is	595 days.
The efficient period T−t is	310 ,,
Giving an efficiency of (E)	·52

The length corresponding to (E) = ·52 and a speed of 10¼ knots from Fig. 10 is 370 ft., but this reduced length is accompanied by a reduced deadweight, and, consequently, an increased efficiency. This variation in efficiency suggests that a length of 380 ft. might be tried, and the particulars would then be—

Deadweight (from Fig. 13)	7,050 tons.
Time on voyage	310 days.
*Loading and discharging time $255 \times \frac{7,050}{8,000}$	225 ,,
Time for coaling and repairs	30 ,,
Total period T	565 ,,
Efficient period T−t	310 ,,
Giving an (E) value of	·548
The corresponding and final length would then be	377 ft.

* Estimated from the 400-ft. ship in relation to the deadweight.

The detail curves for the condition nearest to this vessel's efficiency show that if the vessel had been 23 ft. shorter the "tons carried" would have been increased by 1 per cent. and the "freight rate" reduced by ½ per cent.

No. 2.—Proposed vessel for service between Bombay and Glasgow, or neighbouring ports, a distance of 6,500 nautical miles. Speed on

service, 11 knots. Full cargoes can be obtained on all voyages, and it can be handled at an average of 150 tons per derrick system per day. Swinging derricks only to be arranged for, and the cargo can be handled over both sides of vessel at Eastern ports, but will be worked to and from a quay wall in Britain. The vessel will bunker before embarking and also at an intermediate port on each voyage. What is the most suitable length ?

Try lengths of 360 ft., 400 ft., and 440 ft.

Lengths	360 ft.	400 ft.	440 ft.
	Tons.	Tons.	Tons.
Gross deadweight, per Fig. 13 ..	5,750	7,750	9,900
Less coal for half-voyage ..530 }	630	740	850
Less stores, fresh water, &c. ..100 }			
Nett cargo to be handled ..	5,120	7,010	9,050
Number of derricks on each side	8	9	10
Estimated time per trip -	Days.	Days.	Days.
Time to load at Bombay .	4·27	5·20	6·03
Time to discharge at Glasgow .	8·54	10·40	12·06
Time to coal on route .. .	2·00	2·00	2·00
Time for shifts in harbour, &c., and all other delays .	3·00	4·00	4·00
Total lost time .. .	17·81	20·60	24·09
Total time at sea .. .	24·60	24·60	24·60
Total time per trip . ..	42·41	45·20	48·69
Efficiency $\left(\frac{T-t}{T}\right)$	·58	·545	·50
Lengths, per Fig. 10, for these efficiencies	402 ft.	389 ft.	376 ft.

Column 2 gives the best agreement between the trial and the resulting lengths, and the most suitable length would be about 395 ft. long.

No. 3.—Vessel 600 ft. long engaged on a voyage of 5,000 nautical miles, and having a service speed of 12 knots. Thirteen derricks are arranged on each side, and these load or discharge from lighters on each side at each terminal port, each at the rate of 200 tons per day. Is this the most suitable length ?

Gross deadweight (from Fig. 13) ..	23,500 tons.
Less coal, stores, fresh water, &c.	1,900 ,,
Nett cargo to be handled	21,600
Time required to load and discharge $\frac{21,600}{26 \times 200} \times 2$ ..	8·3 days.
Time required for coaling and shifting . ..	3·0 ,,
Average time lost for repairs, &c., per voyage .	2·7 ,,
Total lost time per voyage	14·0 ,,
Total time sailing	17·4 ,,
Total time per trip	31·4 ,,
Efficiency $\left(\frac{T-t}{T}\right) \frac{17·4}{31·4}$	·555

Length corresponding to this efficiency from Fig. 10 = 412 ft.

It is evident that the efficiency will improve considerably with this reduced length, and on this account a length of 400 ft. having 110 winches each side might be tried.

The particulars would then be—

Gross deadweight (Fig. 13) .. .	10,700 tons.
Less coal, stores, fresh water, &c. ..	1,200 ,,
Nett cargo to be handled	9,500 ,,
Time required to load and discharge $\frac{9,500}{20 \times 200} \times 2$.	4·75 days.
Time required for coaling and shifting	2·45 ,,
Average time lost for repairs, &c., per voyage	2·0 ,,
Total lost time per voyage ..	9·20 ,,
Total time sailing	17·4 ,,
Total time per trip	26·6 ,,
Efficiency	·654
Corresponding length ..	400 ft.

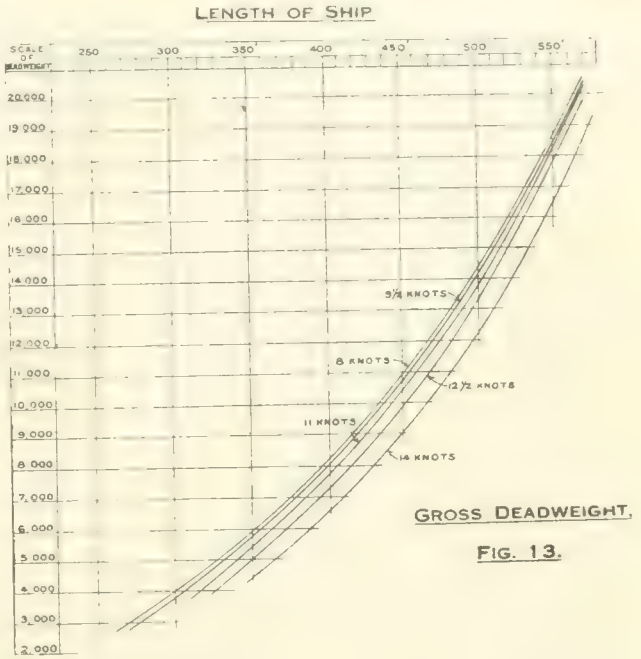


FIG. 13.

This smaller vessel would transport 15 per cent. additional cargo in relation to the initial cost, and the freight rate would be reduced by about 4 per cent.

The writer is not aware of any existing vessel of the basis particulars in this latter case, but such a length, speed, and length of voyage has been suggested by Sir John Biles in his paper to the Institution in the year 1900.

Table III gives the actual working qualities of seven vessels, and indicates how their lengths as built compare with the calculated lengths.

TABLE III.—*Particulars of the Working Qualities of Cargo Ships compared with the Calculated Results given by Fig.* 10.

No.	Trade Route.	Approximate Length of Voyage.	Length of Ship.	Service Speed (Knots).	Total Time per Trip (Days).	Steaming Time (Days).	Corresponding $\left(\frac{T-t}{T}\right)$ Value.	Length to fit Curves, Fig. 10.*	Remarks.
			Ft.		T	T−t		Ft.	
1	Liverpool and United States .	8,500	410	10·25	63	34·[illegible]	..	390	Round voyage, outward in [illegible] voyages.
2	Liverpool and United States .	11,000	465	10·60	82	47	573	382	Round voyage, outward in ballast, average of 3 voyages.
3	Liverpool and Far East .. .	25,000	390	10·70	140	[illegible]	·665	420	Average of 4 round voyages.
4	Liverpool and Pacific Coast ..	30,000	503	13·00	161	94	·585	[illegible]	Average of 4 round voyages.
5	Liverpool and Far East .. .	25,000	452	13·80	128	71	[illegible]	445	Result of 1 round voyage.
6	Leith to Far East	25,000	390	10·30	182	105	·577	388	Result of 2 round voyages.
7	British and Continental Coasting	1,500	215	8·0	16	7·[illegible]	445	270	Result of [illegible] years' service.

* Corrected for change of efficiency due to change of length and number of derricks in terms of gross deadweight.

A PRELIMINARY SURVEY OF THE POSSIBILITIES OF REINFORCED CONCRETE AS A MATERIAL FOR SHIP CONSTRUCTION.*

By Major Maurice Denny.

So long as the efficiency of a mercantile marine is judged by its dividend-earning capacity in free competition, so long will the choice of material for the construction of its units depend on economic considerations. Up to the present for the general trader, steel has proved to be the material which gives the greatest return for capital invested, and no material inferior in this respect will permanently displace steel from this position.

In the abnormal circumstances now prevailing, however, reinforced concrete suggests itself as an alternative to steel. As the use of reinforced concrete makes practically no demand on the class of labour and material used for steel shipbuilding, the justification for its trial is sufficient, and, in these times, overwhelming.

Experience has proved that steel embedded in concrete is completely protected from corrosion. It has been found that steel which was slightly corroded when bedded, after a lapse of time has shown no trace of rust, which apparently has entered into chemical combination with the surrounding concrete and formed an impervious coat. This is fortunate, since the tensional strength of all parts of the structure of a reinforced concrete vessel is solely supplied by the steel. It is obvious, however, that if the envelope of concrete be ruptured in such a manner as to allow water or other corrosive substance to come in contact with the steel deterioration will at once set in, and will be the more dangerous in that its presence may not be readily detected. There is every reason to expect cracks in the tensional side of a reinforced concrete member, even when the steel is not stressed beyond a very moderate working load. The volume of opinion seems to be, however, that these cracks are minute and do not permit the ingress of liquid, nor impair the efficiency of the member as a whole. In this connection it should be noted that in a ship's structure the stresses are frequently alternating, often of indeterminate magnitude, and may partake of the nature of shocks. Marine conditions seem thus to be more severe than have usually to be provided for in land work. It has yet to be shown that minute cracks, which are negligible in land structures, may not in marine work develop into fissures sufficiently wide to permit the entry of water, or even, as the result of internal abrasion due to reversal of stress, form cavities sufficiently great to destroy the unity of the member as a whole.

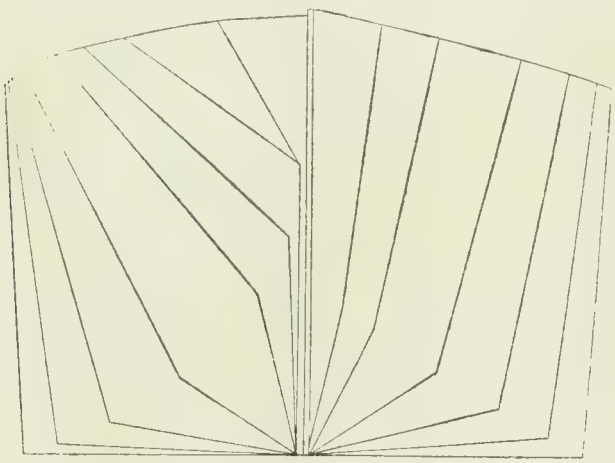


Fig. 1.—Simplified Form for Concrete Ships to reduce Possibility of Damage at Bilge.

The repairing of local damage in a reinforced concrete ship would seem to be a relatively simple matter. So soon as sufficient concrete and steel in way of the damage has been removed to allow of an adequate scarph between old undamaged and new reinforcement, fresh concrete can be poured into place. Since concrete "sets" under water it is not necessary to retain the vessel in dry dock during the initial stages of hardening. The actual time required for "weathering" will depend on the structural importance and extent of the damaged portion, and unless this is considerable, the vessel can return to service after a much shorter lapse of time than was necessary between launching and delivery.

Watertightness of Concrete Ships.

Watertightness is one of the points which the naval architect will most critically examine when the question arises of replacing steel by reinforced concrete. It is possible to draw certain inferences from the behaviour of large tanks in land work. Apart from the water-resisting ability of simple concrete there are various methods of treating the material which fall generally into two categories:—(1) The addition to the concrete during mixing of a waterproofing compound; (2) the treatment of the finished surface with a suitable non-porous material. The first of these is generally believed to reduce the strength, and in the present position of the industry the naval architect will be chary of adopting it. The second comprises: the treatment of the surface with cement mortar well rubbed into the pores, coating with a special mixture, and painting as in a steel ship. Even when none of these special precautions is taken, experience in large tanks shows that though leakage occurs when the concrete is first subjected to water pressure, it gradually diminishes in quantity and finally ceases altogether. It is interesting to note that, even in this early stage of development,

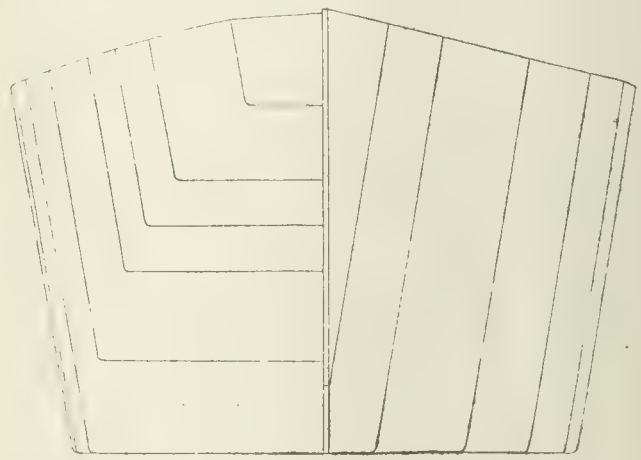


Fig. 2.—Simplified Form for Concrete Ships to secure "Flare" at the Bows.

reinforced concrete vessels are being built to carry fuel oil in bulk, experience with land storage tanks and experiments recently made indicating that mineral oil has little or no destructive effect on the material.

Concrete is much more susceptible to abrasion than steel. The small component particles are rather readily detached from the mass and adequate shielding must therefore be arranged in way of the chafe of cables, cargo, steering chains, &c. If this precaution be neglected the steel reinforcement may be laid bare with the consequent danger of corrosion.

The ability of reinforced concrete to stand vibration, whether from propelling or deck machinery, may be called in question. The experience afforded by railway bridges and factory floors shows that little trouble need be feared from this cause, provided that the concrete is not allowed to fail progressively by unsuitable distribution of attachments.

Weather Conditions.

At certain seasons of the year the construction of reinforced concrete vessels may be adversely affected by climatic conditions, a consideration entirely absent from steel shipbuilding, except in so far as the human element is concerned. In frosty weather concreting must not proceed at all, and too rapid drying must be guarded against in the presence of strong sunshine or high winds. After the vessel has been constructed, however, it does not appear that atmospheric influences have any considerable effect; piles in salt water exposed to very severe conditions in the form of alternate wetting and drying at all seasons of the year showing no signs of deterioration.

Concrete when being worked is a plastic material. Except in one particular method which will be noted later, the whole of the outer and inner surfaces are bounded by a suitable material, the concrete being "cast" into the space between. It is an obvious economy to arrange that several vessels shall be cast from the same moulds.

* Abstract of a paper read at the Fifty-ninth Session of the Institution of Naval Architects, March 22. Discussion will be found on page 364.

This has a marked effect on standardisation of type. Where wood is used for the moulds it will probably be found that from five to eight vessels can be built from one lot of shuttering, though considerable repairs and renewals to the woodwork will only be avoided by skilful design and care in erection and dismantling.

Modified Lines.

It seems evident that if the usual ship form be adopted, in which there is curvature in two directions, the amount of work entailed in shaping the shuttering will be at its maximum. The best result from the point of view both of the naval architect and the reinforced concrete engineer must be sought among the class of "straight frame" forms, which yields at once reasonable figures for resistance in association with curvature in one direction only. Two suggested compromises are shown in Figs. 1 and 2, the "batter" of the sides in Fig. 1 being given in order to reduce the chances of possible damage at the sharp bilge when lying alongside quay walls, and in the case of Fig. 2 to secure "flare" at the bows.

In order that the shuttering may be used several times, it must be so arranged that dismantling does not involve the destruction of the integral parts, and it must be so treated on its inner surfaces that the concrete does not adhere to it. It must be noted that both the interior and exterior walls, or shutters, are not completed before "pouring" commences. The relatively small space between the walls or shutters, threaded as it is by a network of reinforcement, offers such resistance to the passage of the concrete as to render abortive all attempts to pour through long distances. Only one wall, therefore, is completed, and the other rises in stages as the concreting proceeds.

Degrees of Plasticity.

The more fluid the mixture the easier it is to work at this stage; but an excess of moisture brings in its train undesirable qualities in the finished article. On the other hand, it is difficult to ensure that a very dry mixture shall fill all the cavities, and the "setting" is apt to be too rapid. A judicious compromise between these two extremes gives scope for the exercise of care and skill on the part of the workmen engaged on the construction.

Before any concrete is poured, the reinforcement must be placed in position. This is one of the operations which brings into relief the much greater difficulty of marine work as compared with land construction. The accurate placing of the steel and its retention in the correct position is at once of considerable difficulty and great importance. To keep the reinforcement in position before, and during, pouring the component members are wired together so that the reinforcement as a whole assumes the character of a semi-rigid skeleton. The wiring is not taken into account in the strength calculations.

A typical midship section and part profile are shown in Fig. 3.

Monolithic v. Sectional Systems.

The majority of present-day reinforced concrete designs are based on the production of a vessel which should be cast in one operation, the "monolithic" method, and the foregoing remarks on construction have primarily reference to a monolithic ship. The alternative method is to cast the integral parts separately and assemble them at the slip—the "sectional" method.

In the monolithic method, in order that there should be no natural cleavage lines between adjacent areas of concrete in the completed vessel, the pouring would have to proceed continuously and fairly rapidly from the commencement. The large number of hands necessary to make the pouring a continuous operation, and in addition to effect the concurrent erection of the shuttering, renders impossible the production of a truly monolithic structure in all but very small ships. In practice, large areas are allowed to "set" before the pouring of the adjacent material is commenced, precautions being taken to ensure that the junction of the old and the new material is efficient by the employment of a pure cement "grout" as an adhesive layer. The lines of cleavage are not discernible in the finished product, but precautions are taken to "stagger" the junctions after the manner of butts in shell and deck plating of a steel ship. Notwithstanding the possibility of making joints, it is undesirable to have marked discontinuity of pouring.

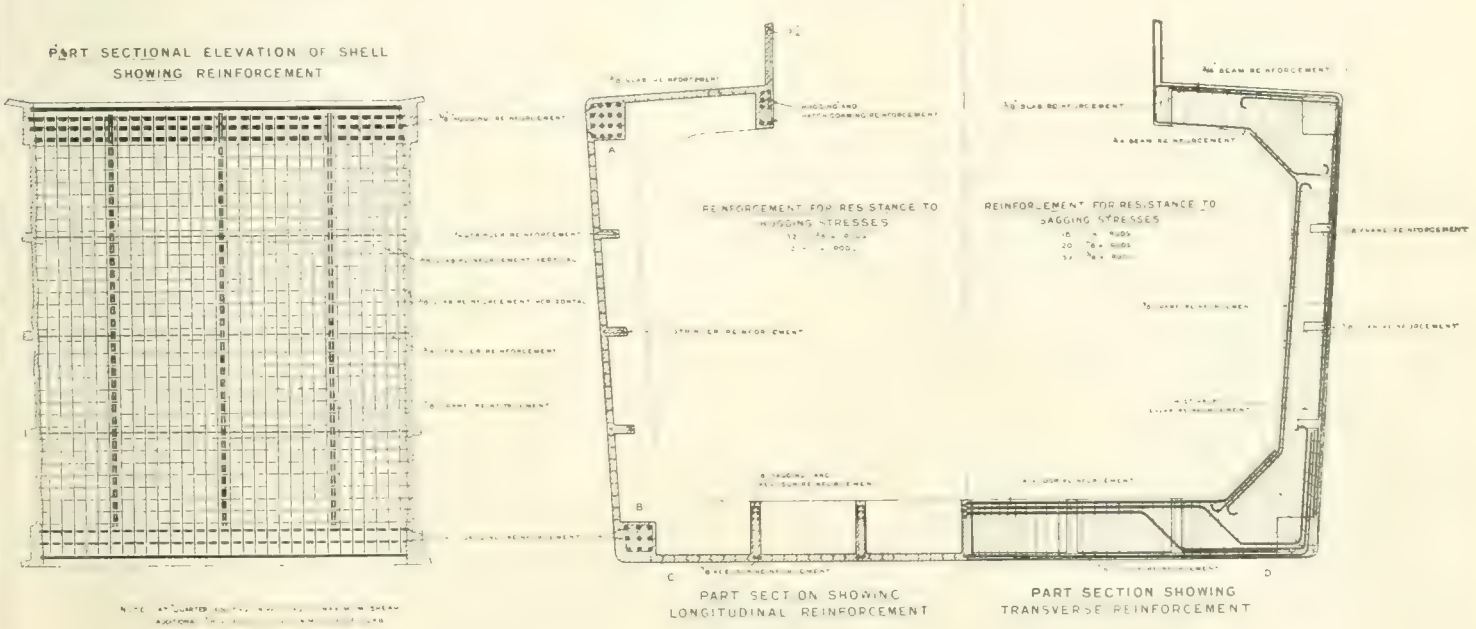


Fig. 3.—Cross-Sections and Part Sectional Elevation showing Reinforcement.

When attempting to produce a monolithic structure as an alternative to simple pouring it may be noted that it is possible to apply the concrete by means of a spray, somewhat after the fashion of a sand-blast. A vessel has been built abroad by this process, and experiments are now proceeding in this country. Whether this method will prove more satisfactory than the other will be shown only by the results of practice.

In the "sectional" method portions of the structure more or less extensive are cast from moulds which should be capable of being used a large number of times. A vessel whose sides have irregular curvature, or one in which there is no great extent of parallel middle body, is evidently ill-suited to this form of construction. The sections are assembled in place, and in addition to the "grouting" referred to above, steps must be taken to provide for continuity of the local reinforcing material. As it is impossible to allow the general longitudinal reinforcement to be broken abruptly, it is obvious that it cannot form part of the sections, and must therefore be placed in position separately from them. As an example, the shell with its frames between the points A and B, and the bottom with the floors between the points C and D (see Fig. 3), might be cast in sections, which, in the fore and aft direction, may be either one or many frame spaces in length. After the sections are assembled the longitudinal reinforcement at gunwale, bilge, &c.,

would be placed and the concrete poured round it. The advocates of the sectional system state that watertightness is not difficult of attainment, and that cracks due to the contraction of the concrete on setting are less likely to develop than in the monolithic ship.

The sectional system dispenses with a considerable amount of shuttering, and is susceptible to standardisation of parts to a much greater degree than is the monolithic system.

Launching Problems.

The launching of a vessel subjects the structure to local stresses which may be of considerable magnitude. The steel vessel at the time of launching is as fit to resist these as she ever will be. The process of maturing concrete extends over a period of years and, as might be expected, the increase of strength is very rapid over the early part of that period. By constructing the vessel in such a situation that she may be waterborne without subjecting her to stresses as severe as those imposed by launching, the necessary period of delay between the completion of pouring and floating is reduced. The advantages of floating from a dock, however simple or elaborate it may be, as distinct from launching, are :—

(1) The possibilities of failure of the structure during removal from the building berth are much reduced.

(2) The number of berths required to execute in a given time any programme is reduced owing to the fact that the number of ships lying " weathering " on dry land is less.

(3) The ground can be permanently levelled and prepared so as to form the exterior surface of the bottom shuttering, whereas bottom shuttering is always required (at least in a monolithic vessel) where launching is contemplated.

Scantlings and Suitable Mixtures.

Concrete suitable for ship construction must be of the highest quality in order to ensure watertightness and to reduce the quantity of the material used. A suitable mixture would have the following composition by volume :—Cement, 1 ; sand, $1\frac{1}{8}$; coarse material, $2\frac{1}{4}$. The permissible working stresses for this mixture would be as follows :—Direct compressive, 730 lb. per sq. in. ; shearing, 73 lb. per sq. in. The tensile strength of any concrete mixture is so low that all text-books and regulations agree in placing it at zero for practical purposes.

The fact that reinforced concrete is not a homogeneous substance introduces methods of calculation which are not familiar to the naval architect, who is usually dealing with a material reasonably assumed homogeneous.

Lacking rules for the determination of the scantlings of reinforced concrete vessels, a solution may be sought in either of two directions :—(*a*) By the application of first principles, or (*b*) by attempting to provide the same strength as is found in corresponding elements of a steel ship.

That the latter method will be proved in practice to be the more satisfactory is open to doubt. As is well known, a deliberate provision for corrosion is made in steel vessels, the amount of this being largely independent of size, and allotted to the different elements of the structure in varying degree. If allowance is not made for this a provision to resist corrosion in a steel vessel would appear as a provision to resist stresses in a concrete vessel in which corrosion is absent. Furthermore, for instance, the determination of the moment of inertia of a frame element, in a steel vessel, which is to be repeated in a frame element of a reinforced concrete vessel, requires the inclusion in each case of an indefinite quantity of shell plating ; and the results will vary unduly according to the choice made.

Weight of Concrete.

The weight of a cubic foot of plain concrete is about 145 lbs. The weight of a cubic foot of reinforced concrete naturally depends on the percentage of steel included therein. For land work the figure for the percentage of area of steel to area of reinforced concrete ranges from 0·5 to 1·5. Taking for the moment a percentage area of steel of 1, the weight of reinforced concrete is about 150 lb. per cub. ft., when steel is 490 lb. per cub. ft. The relative weights are therefore 1 : 3·3.

The mixture quoted, when reinforced with 1 per cent. of steel, has a permissible compressive stress of 810 lb. per sq. in. The relative strengths are therefore 16,000 : 810, or 19·8 : 1. This elementary consideration shows that for the same conditions the relative weights are $\frac{19 \cdot 8}{3 \cdot 3}$: 1, or 6 : 1. As will be seen shortly, the area of reinforcement in a 1,000-ton vessel is more nearly 4 per cent. than 1 per cent. of the area of reinforced concrete, which reduces the ratio roughly to 4·5 : 1. Again, considering the case where 3 in. of reinforced concrete corresponds to 0·4 in. of steel (an actual case for a large barge), the relative weights are 0·4 × 490 : 3 × 150, or 2·3 : 1.

It is found that the percentage of reinforcement steadily increases with size of ship. Thus, average figures for percentage weight of steel to total weight of reinforced concrete are, for a 500-ton barge 11 per cent., for a 1,000-ton barge 14 per cent., for a 6,000-ton steamer 22 per cent. This last figure corresponds to a percentage area of steel to reinforced concrete of about 7 per cent., and when it is recalled that an average figure in land work is about 1 per cent., the much more onerous requirements of marine construction are again emphasised.

Loss of D.W. Capacity.

The shipowner is chiefly interested in the loss in deadweight carrying ability. If a vessel of the same dimensions as the 1,000-ton concrete barge noted above had been built in steel, she would have carried somewhere between 35 and 40 per cent. more deadweight.

The quantity of steel required in this reinforced concrete vessel is less than one-third that used in the steel ship, but the finished hull weight is nearly twice that of the latter, even when allowances have been made for the omission of cement and paint in the heavier ship. Where internal volume is the measure of the carrying capacity of a vessel, this increase of weight, though not without its drawbacks, is not vital, but where deadweight is the governing factor, the advantages are heavily in favour of the steel structure.

Steel and Concrete Ships Compared.

The following is a comparison of the technical particulars of the 6,000-ton deadweight steamer mentioned. It is observed, however, that while the figures quoted for the steel ship are probably accurate, the weight of the reinforced concrete hull is purely estimated, represents a much larger vessel than has yet been attempted in the new material, and lacks the confirmation of practice. With this proviso it may be added that it seems reasonable, though without erring on the heavy side.

	Steel.	Reinforced Concrete.
Length	375 ft.	375 ft.
Displacement	9,900 tons	9,900 tons.
Steel	1,920 tons	680 } 3,150 tons.
Concrete	—	2,470 }
Wood and outfit	400 ,,	350 ,,
Machinery	570 ,,	570 ,,
Lightweight	2,890 ,,	4,070 ,,
Deadweight	7,010 ,,	5,830 ,,

From the above it will be noted that 1,180 tons of deadweight is lost, or 17 per cent. of that carried in the steel ship ; that the bare hull of the concrete ship is 65 per cent. heavier than that of the steel ship, and that the light weight of the concrete ship is 40 per cent. greater than that of the steel ship.

The following figures represent a reasonable analysis of the manner in which the total cost of the 375-ft. steamer would be made up if built in steel :—Bare hull, 53 ; machinery, 26 ; remainder, 21 ; total, 100.

If it be allowed that the deadweight carried is a measure of the earning capacity, a reduction of 17 per cent. in this respect must be balanced by a corresponding reduction in prime cost of ship. The reduction in this instance will be 17 per cent. multiplied by 100/53, or 32 per cent. in bare hull cost, since the cost of the other two items remains unaltered. A closer investigation of the question will show that this is only a very rough approximation, and that the absolute cost of running the vessels (even if it be taken to be the same in each case), the percentage of profit assumed, and other matters of accountancy have a powerful influence on the result. These, however, all have the effect of increasing the figure of 32 per cent. noted above, and it can be stated with fair certainty that reinforced concrete will not replace steel for the ordinary cargo carrier unless the hull can be built for considerably less than half the cost of building the same hull in steel. In spite of this there appears to be a class of floating structures in which reinforced concrete may well replace steel.

In the preparation of this paper I wish to acknowledge the assistance of Mr. A. M. Robb, who has been closely associated with the present programme of construction from the beginning.

INSTITUTION OF NAVAL ARCHITECTS.

ANNUAL MEETING.

The annual general meeting of the Institution of Naval Architects was held in the rooms of the Royal Society of Arts, on Wednesday, Thursday and Friday, March 20, 21 and 22. The President, the Earl of Durham, was in the Chair.

Among those present were:—Lord Brassey, S. W. Barnaby, Sir Charles Parsons, F.R.S., H. R. Champness, M. McIntyre, E. Hall Craggs, J. M. Allen, A. W. Simpson, E. W. Sievewright, A. Cannon, J. Duncan Cran, Professor J. J. Welch, A. F. Yarrow, J. F. Cowan, Harold E. Yarrow, W. H. Whiting, Jas. Stewart, A. W. Stewart, J. L. Kent, A. H. Wilson, Leslie Skinner, H. M. Rounthwaite, J. W. Isherwood, J. Peskett, J. Hamilton Gibson, F. E. Smith, J. E. Elmslie, K. G. Finlay, J. Foster King, R. Saxton White, E. L. Orde, Benson Taylor, E. J. Carter, W. D. Archer, C. W. Littleboy, W. H. Higgs, W. Saunders, C. M. Carter, D. W. Caddick, G. G. Deane, E. H. White, J. W. Hamilton, A. B. Wilson, A. J. Dudgeon, C. Fowling, R. W. Allen, H. M. Macmillan, H. Gibson Holman, R. Baillie, G. Scantlebury, Johnston Brand, Professor Sir J. H. Biles, G. R. Jackson, F. E. Pratten, A. T. Wall, John Anderson, Sir George Carter, Professor W. S. Abell, G. S. Baker, Professor H. C. H. Carpenter, Dr. W. H. Hatfield, Professor F. O. Hudson, C. E. Stromeyer, Major M. Denny, Walter Pollock, T. G. Owens Thurston, A. H. Matthews, J. C. Swift, Henry Boyd, R. D. Ewing, W. A. D. Forbes, Andrew Laing, T. B. Abell, Thos. Graham, Andrew Hamilton, A. Macdonald, W. J. Berry, R. C. Hogg, A. S. Younger, Sir Eustace D'Eyncourt, Sir Philip Watts, A. W. Johns, J. F. Redman, W. J. Luke, Captain J. Waller (R.E.), Staff Captain Simpson, F. S. Dudgeon, H. Barringer, Professor W. E. Dalby, Sir Alan Anderson, W. H. Whiting, Sir William Smith, Sir William Llewellyn Thomson, D. B. Morison, Sir George Greenhill, E. W. Williams, B. J. Ives, W. J. Millar, P. R. Bevis, G. H. Bottomley, W. T. Seaton, M. E. Denny, W. W. Bradfield, R. A. Pelmore, J. Anderson, J. Dunlop, C. H. Rugg, E. J. White, J. A. Rennie, R. M. McLaren, Lieut. Y. Tagi (Japanese Navy), W. H. F. Young, J. C. Sellers, Y. Ogawa (Naval Constructor), W. Shiomi (Japanese Navy), Naval Constructor A. T. Tanguni (Japanese Navy) and Lieut.-Constructor K. Saguki (Japanese Navy).

The secretary read the report of the Council for the past year as follows:—

The annual report of the Council for 1917 calls attention to the restriction caused by the war upon the work of the Institution, and congratulates those members of the Institution who have been honoured for their services in connection with the war. The list numbers 75. The membership of the Institution has been maintained, the losses due to death and resignations having been counterbalanced by the election of new members. The total number of candidates of all classes elected in 1917 was 136, the membership now amounting to 2,068, against 2,065 in 1916, and 2,092 in 1915.

The annual gold medal of the Institution for the year has been awarded to Professor G. W. Hovgaard, of the Massachusetts Technical Institute, Boston, U.S.A., for his paper on "The Buoyancy and Stability of Submarines," and the premium to Mr. J. J. King-Salter, R.C.N.C., of H.M. Dockyard, Sydney, for his paper on "The Influence of Running Balance of Propellers on the Vibration of Ships." The Martell Scholarship has been awarded to Mr. H. C. Carey, H.M. Dockyard, Chatham, and the Earl of Durham's prize to Mr. H. D. Leggett, H.M. Dockyard, Portsmouth.

The report was adopted without discussion.

The announcement of the result of the ballot for President and Council was made, the Earl of Durham being re-elected president, the new vice-presidents being Prof. Sir J. H. Biles, the Rt. Hon. Lord Pirrie, Sir William E. Smith, Sir Archibald Denny, Engineer Vice-Admiral Sir Henry Oram, the Rt. Hon. Sir Charles Parsons, Sir Alexander Gracie, Mr. S. W. Barnaby, Mr. R. Saxton White, Mr. J. Foster King, Sir Thomas Bell, Engineer Vice-Admiral Sir G. J. Goodwin, Mr. Andrew Laing, Sir Eustace D'Eyncourt, Mr. W. H. Whiting, and Mr. James Bain. The new members of council are W. J. Berry, John Gravell, James Hamilton, Sir G. B. Hunter, A. W. Johns, W. J. Luke, Sir Herbert B. Rowell and Mr. Harold Yarrow. The associate members of council are Prof. W. E. Dalby, the Rt. Hon. Lord Inverclyde and A. Richardson.

The president said that, as the winners of the gold medal and the premium were both absent from the country, it was impossible to make the presentation in person. They would be forwarded.

The Presidential Address.

Addressing the members, the president said he did not propose to make much reference to the past. They had heard from the report of the losses which the Institution had incurred during the year, and one of the losses would have their utmost sympathy and sorrow. There was one familiar face, one much-respected presence missing from the meeting, namely, Lord Brassey. Death had removed from among the members one whose friendship and long service to the Institution and whose love for it would long be treasured by all who knew him. He was the personification—an admirable type of a generous, large hearted and undaunted Englishman, game to the last, loyal, and true as steel to his native land, and to his Empire. That Empire knew him well and honoured him. The Institution had on innumerable occasions appreciated his wise counsels, his genial hospitality and his never-failing readiness to promote the interests of the Institution. He was sure they would wish to record their sorrow and to express their pride in Lord Brassey's long and most honourable association with the Institution.

He felt that in ordinary circumstances a presidential address should be, and he felt bound to say, generally was, a colourless and non-critical species of essay, but on an occasion such as this at a time of such grave national difficulties, he felt that he would be deficient in moral courage if he did not dare to express his own personal views. They might be right or they might be wrong, but they committed nobody but himself. He therefore proposed to say a few words upon the shipbuilding crisis. He could not disguise his opinion that this most disquieting and most unsatisfactory situation was due in a considerable degree to the paralysing influence which seemed to be inseparable from Government control of national institutions. That the Government must control the operations of the war was a truism which no one would dispute, but that it should personally manage all the productions whereby war was successfully carried on was a totally different proposition. It was true that the Government employed experts and others. It was true that the Institution had 18 members serving under the Admiralty Controller, but they did not control the Controller. During the past few weeks there had been agitations, accusations and recriminations due to the low output of ships. He saw some of his friends from the North of England were present, and he did not think he was misinterpreting their views when he said that they attributed much of the trouble and delay, not to disputes between employers and workmen, not to unwillingness or lack of patriotism on the part of the workmen, but to inexpert interference and the hustling methods of Government officials. There was an obsession, almost a mania, on the part of the Government to interfere with all public and private affairs by overseers, scrutineers, advisers and controllers, but the waste of time by the multiplication of these bureaucracies was positively colossal.

The first paper would deal with the question of standard ships—a much-discussed subject—but he thought, in justice to the Government, he should point out that he understood it was decided to build these ships as an emergency war measure, and with a view to building ships of a certain quality and design as speedily as possible. The idea of standardisation, of course, was no new one to naval architects, and

he understood that ships which might be called by that name had been built from time to time in private yards by individual firms. The infamous submarine warfare accounted for the Government having taken a measure which would not in ordinary circumstances have had any great body of weight behind it. After all, the mercantile marine of this country had by its own enterprise built up our shipping business, and not only must the shipbuilders be credited with this, but we must also remember the readiness of naval architects to design, and our shipbuilders to construct, ships which met the changing needs and varying requirements of the shipping industry. It would be a fatal mistake to deprive naval architects of the individual exercise of their inventive genius, and to limit their work to certain specified standard designs. It would be difficult for the Institution to promote progress if there was to be no freedom given to individual effort in the way of design. He was fortified in that view by the paper which was to be read by Mr. Abell on the future of the design and construction of merchant ships. That paper would demonstrate that there was no finality in standardisation, and it would be well if the Government recognised that fact and allowed shipyards to produce the ships which they were best capable of turning out rapidly. There was one point which was sometimes ignored when the low output of ships was discussed, and that was that the ravages of war had caused an immense amount of repair work to be imposed on shipbuilding yards. In many cases repairs were urgent and took priority of all other work. He was not trying to invent excuses for low output of shipbuilding. Everybody deplored it, and was most anxious to help in every way to increase it. None of the members of the Institution, he was sure, desired to thwart or hamper the Government. They would do all they could to help, but the country did expect that the Government would prove that it was handling this most vital question wisely and properly. Shipowners, shipbuilders and workmen must realise on their side that the country looked to them for the utmost patriotism that they could give. No exertions must be lacking on their part, and he was sure it was unthinkable to all that any petty jealousies or labour disputes should imperil the welfare of our fighting forces or the food supply of our country, or, above all, the untarnished honour of our Empire in its noble struggle for freedom and peace.

The reading of papers was then proceeded with, the first being

Standard Cargo Ships

An abstract of this paper will be found on page 339. The following discussion took place:—

The Admiralty Controller.

Sir Alan Anderson, Admiralty Controller, said he was only capable of speaking on the administrative side of this problem, and that was a very important side, but before doing that he wished to say something on the general question raised in the Presidential Address. Of the many anomalies of war and war business one of the most striking was that everybody in business held the opinion that so far as possible the interference of the Government with private business should be reduced and the fact that one might be Controller did not alter one's views. The best possible way of controlling business was to let business people control themselves. He did not believe there was the smallest division of opinion among business men in this country on this point. In war the Government had to intervene in all sorts of ways which appeared unnecessary to many people and which would be unnecessary and very damaging in peace time. Government interference became a disease, he quite agreed. Occasionally people who were given power to intervene did more than they need do, and in war, just as in peace, what was imposed as a necessary control often became a hampering and an annoying piece of machinery. With regard to the low output, which was well known, there had been a lot of criticism, but the difficulty had been that the facts had not been known. He had held that view very strongly and was glad that the facts were to be published, facts as to the losses and production of tonnage. That would have the effect of getting healthy public opinion directed to the whole business and to the operations of the department over which he presided. That was most important, because in order to criticise it was necessary to know, and there had been a lot of criticism in the papers which would not have been made had the facts been known. He was advised—and the people who advised him were competent shipbuilders—that the output of the yards in this country during 1917 had been an absolute record. It had not been a record in merchant vessels, but it had been a record when they took into account the other craft that had been built—warships, auxiliary craft and the very large increase in essential repairs. That was a very satisfactory thing from one point of view, from the point of view of anyone defending a department, but he was most interested, as they all were, in getting the amount of tonnage that was needed. Instead of getting rid of the difficulty by getting rid of himself or someone else, what was wanted was that steps must be taken to bring a healthy and well organised industry up above a record breaking period to a still more record breaking period, and that was a very difficult operation. That was closely allied to the standard ship, because the Shipping Controller and his advisers, chief among whom was Sir George Carter, saw quite clearly when they began that the ordinary methods of shipbuilding and placing of orders could not be followed. They had to rule out a large number of extravagant types. There had been criticism, and there was bound to be, of what they had done. The world was divided into two sections, the people who liked to manage other people's affairs and the people who resented being interfered with in their affairs. Sometimes a person might occupy both positions at the same time. Personally he was of those who disliked having his affairs interfered with and that class of person naturally criticised the work that had been done under the standard ship policy. No doubt there had been mistakes; there were in every operation, and in business we should never get on unless we were prepared to make mistakes. In war it was necessary to act more rapidly and make more mistakes than in peace. The main lines of the criticism were first, that standardisation was no new thing and that what had been done now was to make builders who had already standardised build some other type of ship, which they did not want to. Other critics said that it was not a standard ship at all. Both arguments were more or less true. It was true that many yards had standardised in the sense the word was now being used, and it was equally true that the present standard ships were not standard ships in the sense of the Ford car, or in the sense that the Americans were already turning out standard ships, or we in this country would shortly be turning out standard ships. What Sir George Carter realised and advised Sir Joseph Maclay to do was, in effect, to rule out all extravagances and to get rid of a whole mass of complications and jealousies which would have occurred had they allowed the private shipowner to place his individual orders and the private builder to build on his own individual ideas. He himself was a shipowner and naturally he liked to be able to place orders for the ship he wanted. At the same time the country owed a very great debt of gratitude to the Advisory Committee for having acted promptly and having got to work on a type of ship which was simple and did its job and relieved the Committee of all complications. He felt quite confident that if the standard ship policy had not been put into force there would have been far graver criticisms against the Government department concerned and it would have been impossible to hold the scales fairly between the different people who wanted to place orders. The paper, he thought, absolutely answered most of the criticism. Having marked out a policy they must go ahead. The cost of the standard ship had been incurred before his time and now there were six types of ship under way, of which the benefit would be reaped very shortly. Another point in the standard ship was the very great reduction in the number of sections. His conclusion was that the country owed Sir George Carter and his colleagues a great debt for tidying up what was a most confused and difficult condition of affairs in the state of shipbuilding in this country, and he hoped that before long standard ships would be turned out in regular and increasing numbers.

Delays and Accelerations of Standardisation.

Sir Eustace D'Eyncourt said there were two important points which must always be borne in mind in connection with standardisation. The first was delay. There was no question but that the adoption of standardisation must, for a time, involve delay. If the Government, for instance, took over the whole of the motor-car industry and decided to build only one type of car—which God forbid—all the works would immediately stop for the time being until working drawings, jigs, and gauges were got out. The same thing applied to the standardisation of ships or anything else. At the present time we were suffering to a great extent from that. The building of standard ships had not yet got into its stride and he did not think it would be realised for some time how much they owed to the Shipping Controller and the Advisory Committee, of which Sir George Carter was chairman, for the work they had done. It was only beginning to bear fruit now, and it would continue progressively to improve he had not the least doubt. That was one of the great arguments against standardisation, viz., that it produced delay; afterwards better results were obtained. The other great argument was that it militated against steady improvement in design, because once they had laid down what they were going to design, it was no use listening to people who

wanted to make improvements. They must go on with the standard design. At the same time the argument for standard ships was stronger almost than for any other machine, because it was necessary to have progressive improvement. There had already been established a tramp boat for cargo work which brought cargoes at reasonable speed and with reasonable economy, and they need not always be straining after improvement in that particular type. The argument against standardisation of cargo boats did not hold so much as it did in the case, for instance, of aeroplanes, in which we were up against an enemy who was continually improving also. Therefore, with boats they must standardise a type and build to it regardless of everything else, at the same time looking forward to the time when it would be possible to make an improvement at one big jump. Always keeping that in view, they must not, however, stop continuity of production.

Minimising Possibility of Sinking.

Mr. S. W. Barnaby expressed the gratification of the committee appointed by the Council at the appreciative remarks that had been made of its work, and it was very pleased to hear for the first time that many of the recommendations of the committee had been embodied in the standard ships. The committee was appointed by the Council for two reasons. One was directly in connection with the standard ships. When the Shipping Controller was appointed, it was felt by the Council that there was a large amount of information scattered about the country, but not reported and not known generally, as to the effect of mines and torpedoes on merchant ships, and it was thought that the Council's duty was, if possible, to collect this information and to put what was valuable in it in the hands of the committee of the Shipping Controller and of those builders who were building emergency ships. The other reason for the appointment of the committee was the serious loss of the large type of mail and passenger steamers. The public had been led to believe that these ships represented the very latest thing in naval architecture—as indeed they did—and it was expected that they would not go down so rapidly as they did. The Council wanted to find out the reasons for both. They were prepared to find that the effect of the torpedo was very severe upon those ships which had never been expected to meet the attack of the torpedo and could hardly perhaps be expected to survive it. It was thought that the blow would be so severe that large areas of the shell plating would be disturbed and rendered unwatertight, and that perhaps even some of the main bulkheads might be carried away by the sudden inrush of the sea in the enormous holes which were made. The committee examined a lot of information and also a number of ships. It was found that neither of these things were true. Large as the hole was, in its immediate neighbourhood, even within a few feet of the edge of the hole, the blading was not disturbed. The riveting was found to be still sound and in no case was it found that a ship, whose bulkheads were designed in accordance with the rules of either of the two great registration societies had given way from the inrush of the sea. It was found that ships were sinking because compartments which were not injured at all became full of water, and it had to be found out why. Three reasons were to be assigned to this. He was pleased to find that the recommendations had for the most part been embodied, and he took it that the reserve coal bunker had been dealt with in the standard designs. One of the weakest points in existing merchant ships was the reserve coal bunker forward and the boiler rooms. The committee did not deal with new ships in its recommendations; therefore they had to take ships as they were. The reserve coal bunker was a very serious thing and it had been dealt with in the standard ships so far as he could see, satisfactorily, by making it watertight. The large passenger ship was a much more serious problem. In a nutshell, the position was this. These large floating palaces had been built to accommodate passengers in the greatest amount of comfort and the ships were not really divided into watertight compartments, as, perhaps they were thought to be. They were divided into compartments which were capable of being made watertight if there was time to do it. In ordinary circumstances they expected to have time, but with the explosion of the torpedo, sudden and violent as it was, there was absolutely no time, whatever the system of closing doors might be. Therefore, the committee asked that all these ships should, if possible, be divided properly into watertight compartments before they went to sea for the closing of the doors and the tunnels. The committee had hoped that the Government would have been able to do rather more than recommend, because things had been getting worse. At the present rate of loss it seemed extraordinarily difficult to hope to build ships as fast as they were being sunk, and if they could only save a few of the existing ships it would be an enormous help, and the steel and the labour which were required to produce one new ship would carry out the recommendations of the committee in a large number of existing ships.

Watertight Subdivision.

Mr. W. H. Whiting said that although the paper suggested many questions regarding the value of standardisation in detail, he would confine his remarks to the author's references to watertight subdivision, and to recommendations of the committee of the Council of the Institution. In peace time the watertight subdivisions of merchant ships was a matter of extreme importance, but to-day it was one of grave urgency, and national safety. He was delighted to hear that the recommendations of the committee had been embodied in the standard ships. That settled the practicability of watertight subdivision because it was being done. The paper, however, emphasised the point that the safety afforded by watertight subdivisions was a question of degree. Of course it was, and in saying that he was not arguing against Sir George Carter but against those who persistently either opposed or discouraged attempts to make watertight subdivision efficient. Although it was perfectly true that the safety obtained was a question of degree, still it was to most men, he imagined, a very substantial matter whether the chance of surviving was 1 in 2 or 1 in 10, and those were probably the limits within which the ships of which they were speaking varied. No ship was unsinkable, and he agreed with the author that the objection to an indefinite increase in the subdivision of a ship was the difficulty of working the ship and the loss of time in handling his cargo. The author made some remarks about the detailed requirements, and those made in connection with type D were, he thought, just a little perturbing and possibly counter to the recommendations of the committee. He would be glad to have an assurance on that point. The author also stated that where watertight doors were fitted they could be worked from an upper deck position. He presumed the doors referred to were sliding doors, the closing of which was necessarily slow and rarely efficient, even if the doors could be shut. It was the form of door which was most readily prevented from being closed either by the deformation of the bulkhead, or as experience showed, by the enormous quantity of water in deadweight which came through, if an adjacent compartment were damaged. The question of the reserve coal bunker forward had been referred to by Mr. Barnaby, and Fig. 3 type D rather indicated that attention had not been given to this point. The difficulty referred represented one of the greatest causes of loss during the war. This bulkhead at the forward end of the stokehole was not watertight at all, and what made the matter even of greater importance was that it occurred in the smallest type of ship of all. Reference had been made to the fact that mention was made for the first time at the meeting of the report of the committee of the Council on this subject. What form did the report take? It was the outstanding fact that ships supposed to have a certain amount of watertight subdivision and therefore a certain degree of safety were lost in greater numbers, and what was equally alarming they went down more quickly than could reasonably have been expected. There was only one tenable conclusion, and that was that bulkheads reputed to be watertight were not effectively watertight at the moment when in practice they were tested. It was known roughly what was the maximum extent of the damage to the bottom of a ship which a torpedo could do and given such injury in a given position in a given ship under known conditions of cargo, it was only a matter of calculation as to what would happen to the ship; whether she would survive or not. Sir George Carter had told them that most of the recommendations of the committee were being applied on the simple standard ships which were being constructed, and that being so, it was not a long inference to draw that these conclusions could be applied also to existing ships. In the ordinary cargo boat the least number of bulkheads was six. The line end ones did not count, as they only cut off comparatively small portions of the ship. The committee simply recommended that the remaining four bulkheads should be made efficient. Of these four, the second bulkhead was forward and nine times out of ten was watertight. It was therefore the remaining three which it was essential to make watertight for the safety of the ship. No more pressing question of national interest existed to-day than that, and what was needed was that the recommendations of the committee should be enforced. They had been communicated to the Department concerned, and had been received favourably, yet the fact remained that ships

continued to go down, and so long as these recommendations were not enforced by the Board of Trade these losses would continue in their present numbers. This question of watertight subdivision had been pressed on the authorities for the past 40 years, and it was high time that in the national interest the matter should no longer be deferred. The question of passenger vessels was outside the scope of the paper, but the author made a casual reference to it, and therefore he presumed it was not outside the proper limit of discussion. He affirmed, and there was no one who could contradict it, that in the matter of proper subdivisions, grave as the problem was for merchant and cargo ships, the position was even graver still in regard to passenger and mail vessels.

Lord Brassey, after expressing his gratitude to the President for his kind reference to his father, said he agreed that the less interference there was by the Government with the shipbuilding yards the better. It was a significant fact that the reports of the Commissioners last year on industrial unrest in almost every case attributed at any rate some of the trouble to interference between the men and their employers by some Government department in London which was not altogether acquainted with the facts of the case. Some Government control there must be in the shipbuilding industry, but he was quite sure they could leave it to the masters and men in each yard to increase the output. He spoke with some experience, because he was managing director of a lead smelting business in Italy and had been out there until quite recently. All the business of that concern was for the Italian Government, and it was the only one which was not a controlled establishment. When he suggested that the business should be controlled by the Government he was strongly warned against it, and he found that the experience in Italy had been the same as it had been in this country. Most of the disputes between masters and men had been in controlled establishments. In conclusion, Lord Brassey said it was his intention to re-establish the publication of the *Naval Annual* as soon as the war was over.

Mr. Isherwood on Unsinkable Ships.

Mr. J. W. Isherwood did not think Sir George Carter had justified the standard ship nor the policy of standardisation decided upon. He differed from the author that good results had been obtained; far from it. We had experienced a most appalling failure, as shown by our shipbuilding output for January and February. The idea of standardising ships was not new. If the first of the author's summarised advantages had been achieved it would have placed our shipbuilders in the position of being able to dispense with their drawing-office staff, but the fact was that many builders who were at work on the so-called standard ships had prepared their own constructional drawings and also the rolled steel specifications. It could not with accuracy be argued that it was necessary to standardise ships to reduce the number of steel sections to be used for shipbuilding purposes, and he joined issue with the author as to the enormous number of steel sections alleged to be used in shipbuilding in pre-war days. The author appeared to be going back many years and did not seem to have been familiar with the fact that for many years builders had been reducing the number of sections. Even though Sir George Carter had joined the Advisory Committee he did not seem to have come in contact with cargo tramp construction and the practice both here and in the United States of reducing the number of sections. He himself had suggested in 1916, before the Advisory Committee was formed, how the number of sections could be reduced, and if his advice had been adopted there would have been no difficulty in allocating the steel orders. But standardisation of steel sections was not an unmixed blessing, for it resulted in the maker having to go through all sorts of formalities and to be continually under Government control. When it was remembered that there were 12 types of standard, including the coaster type, standardisation was surely a misnomer. It had brought about disorganisation and stoppage of work without any contra advantages. Could anybody imagine Ford, the originator of modern standardisation, designing 12 standard types of motor-car? Had shipbuilders been allowed to build their own standard ships, and especially the North-East Coast builders, there would not have been disorganisation, but friendly emulation. There would have been enthusiastic co-operation and not apathetic resignation, as had been stated by one engineer. The author had referred to so-called unsinkable ships, but he did not do them justice nor did he make any attempt to do so, but seemingly dismissed the idea in a manner characteristic, not of Sir George Carter, but of the Committee of which he was chairman. It was true that any responsible naval architect could design an unsinkable ship, but the author was not correct in saying that in every case such ships required the expenditure of steel per ton of deadweight carried. The disadvantages mentioned in the paper as reasons for the non-adoption of the unsinkable ship were trifling, and some of the alleged disadvantages existed only in the imagination. Conservatism and prejudice stood in the way of an honest attempt being made to devise an unsinkable ship. A design of unsinkable ship had been published which he had prepared himself, and, in contradiction to the statement in the paper that an unsinkable ship required more steel, he maintained that this design would carry 3·67 tons deadweight per ton of steel against 3·4 tons deadweight per ton of steel carried by the standard D type of boat, and this latter was an easily sinkable type. The carrying and handling arrangements were increased but not complicated, as was suggested in the paper, and he had been informed by competent experts that such a ship could be handled in the loading and discharging of its cargo in less time and with less difficulty. If the author had written down an estimate of the saving of life by the adoption of the unsinkable ship and the enormous gain to the nation in the saving of foodstuffs as a set-off against the alleged disadvantages he would not have dismissed the matter so lightly as he had done. Not on one single occasion had the saving of life been mentioned, nor was there any evidence to show that it had been in the minds of the responsible authorities. The opponents of the unsinkable ship were assuming a great responsibility, for the figures showed that 2,938 ships were sunk last year.

Mr. C. W. Littleboy said there was a great deal in what the last speaker said with which he agreed and there was much with which he disagreed. On behalf of shipbuilders who had to construct standard ships he asked that there should be no more alterations in structure. He believed the Committee was endeavouring to reduce the number of parts of deck machinery, and he hoped they would do that as far as possible. When that was done delivery would be expedited. Hinged masts also took up a lot of time to handle, and if they were only single masts it took more time. Indeed, he wondered whether hinged masts were really necessary at all. The first thing that could be seen on the horizon was the smoke from the funnel, and if that was so, what was the use of making the masts fall down? The shipbuilders of the country appreciated the work which Sir George Carter and his colleagues had been doing for the past three years. Mistakes had been made, as was only natural, but now that the initial stages of standardisation had been got over builders were anxious to get on.

Central Control Indispensable.

Mr. T. Graham said he spoke because he had had the opportunity of visiting nearly all the shipyards of the country and had seen the multitude of method and great variety of conception of procedure. Mr. Isherwood had put forward an unsinkable ship and he would like to ask him one or two questions about it. Was it not the case that his magnificent results were obtained, first, because he installed a watertight twin deck, and secondly, because he assumed an exceptionally low permeability which, after all, was the bedrock of calculation, and if they were going to assume, in an arbitrary combination, a low permeability, it was possible to make any result they desired. As regards the standard ship, he did not think anyone could doubt that central control, whatever the design, was absolutely indispensable at the present time. It had been said that standardisation had militated against the development of cargo ship design, but he felt that standardisation, as it affected ships, had been looked at rather from an obtuse angle in some quarters. Standardisation was not a result, it was a process. If they were going to have the standard ship they must have a standard plant and shipyards, and the logical result of that was to develop the plant and yard on a uniform basis. There was experience of that in the construction of destroyers. These had developed from year to year, and yet in them we saw standardisation in its highest form, including the habits of the men. He mentioned this because he had seen some of the ships that were being built for the Shipping Controller, and he almost despaired of ever getting this manufacture on a uniform basis. The only way was to wait for a lapse of time, after which there should be a systematic and rapid output of ships.

Mr. James F. Cowan said that, although the standard ship might not be all that was hoped for, yet there was no sign of its going out of existence. He himself had urged from the beginning the adoption by the Advisory Committee of the policy of the standard ship. He had recommended, in 1916, that a small committee of men of sane

and clear vision—men, who by their past record for rapid ship and engine construction, had proved themselves to be organisers—should be appointed to have full and absolute control of the arrangements. Secondly, that Government Departments as such, or registration societies as such, should have no voice in the management of this scheme, as the success would be grievously imperilled if red tape or anything like working on grooved lines was allowed to manifest itself. The lack of a plentiful supply of modern ships, however, had been due to excessive control of Government Departments, and in these days of rations he fancied that every shipbuilder would welcome the rationing of controllers.

Sir George Carter had stated that in spite of the difficulties and diverse opinions held by responsible shipbuilders and engineers, the policy of the standard ship had been loyally accepted by them. He concurred, but while doing so he wished to point out that there were such things as active loyalty and latent loyalty. Active loyalty consisted in doing the job of oneself, but latent loyalty consisted in leaving it to others. Enthusiasm was the mainspring of loyal effort, and either employers or workmen could be described as enthusiastic for the standard ship. There was a haunting fear of what was going to happen next. They had got into the habit of expecting something to be done by leaving something undone.

Alterations in a ship after it had been once ordered were a perpetual source of worry and annoyance. He had estimated the cost of many thousands of pounds' worth of ship alterations, but in no case had he found that the money received for the work done adequate when he took into consideration the disturbed and demoralising effect on the workers who carried out the alterations. That was much the position with the standard ship and he felt convinced that an increase in production could only be obtained by arranging for some return to the individualistic shipbuilding practice of pre-war days.

Sir George Carter, replying to the discussion, agreed that the output of merchant shipping could have been very much increased had the matter been left in the hands, or the advice taken, of those who knew most about it. Replying to Mr. Barnaby and Mr. Whiting, he had already mentioned that practically all the recommendations of the Committee had been adopted in the ships that were under discussion. He felt that neither himself nor the Committee need offer any excuse for what had been done in the matter of standard ships. The question had been treated by the newspapers in a parochial and not an Imperial spirit. It was well known that on the North-East Coast and elsewhere there were splendid merchant ships—pure cargo carriers—being built, and it was acknowledged that those builders could turn out as good a ship as the Committee, or any other body, could design or think of. There were, at the same time, a very large number of firms, including some of the biggest yards, who had not done this work at all, and the Committee had in mind these firms. As an instance, he mentioned the big Irish firm of shipbuilders. They were fortunate enough to get the material, and on being furnished with the necessary drawings, they easily did what anyone in this country could do, when working on any size, viz., build the standard ship in six months.

With regard to delay, it was all very well blaming the standard ship, but it was impossible to put down a ship if the berth was not vacant. When the standard ship programme was started, all the berths were full, but as the berths emptied, standard ships were put down. It might not be generally known that there were only 65 per cent. of berths available for Government work. That was his answer as regards the greater part of the delay during the past year. He did not think it necessary to follow Mr. Isherwood. The Committee did consider the Isherwood system, and, probably, if they had adopted it, Mr. Isherwood would have said it was the ideal system, and the best thing that could have been done. It would, moreover, have saved Mr. Isherwood the necessity of advertising his system.

As to there being twelve standard ships, the Advisory Committee and the Controller were only responsible for five; they had nothing to do with the other seven. As to alterations, it would be well if some people did not talk so loudly with regard to alterations. The principal alteration had been the converting of 30 tramp steamers into vessels capable of carrying oil, and that was done under urgent Government orders. The only other alterations that had been made were in the living quarters for the crews, and these were so trivial in the shipbuilding sense that he was surprised that anyone calling himself a shipbuilder should take any notice of them.

The second paper, an abstract of which will be found on page 345, was

"The Most Suitable Sizes and Speeds for General Cargo Steamers,"

by John Anderson.

In the discussion which followed, Professor J. J. Welch said that the deductions which Mr. Anderson had reached were, in most cases, borne out by the actual examples. One point fully brought out was that relating to derricking facilities. There was no doubt that the terminal facilities had a great deal to do with the possibility of working a ship economically. Any increase in such facilities at the terminal ports, or in the handling appliances on board the ship, would be a distinct advantage. With regard to the question of the proposed deepening of trade routes, he was not sure that the order suggested was the right one in which to proceed. It seemed to him that the deepening of trade routes and the improvement of terminal facilities should be concurrent. He was not quite clear why the intersection of the two lines shown in the diagram (p. 345), should give the appropriate length of ship. The appropriate length was taken where the loss due to the extra coal and crew per ton d.w. was equal to the losses in invested capital due to the detention per ton d.w. He was not clear why that should give the best length of ship when the two losses were equal. It might, however, be due to the method of plotting, but it seemed to him that the best length would be when the sum of the losses was a minimum. In the case under consideration the sum of the losses would be always a common ordinate; twice the common ordinate would be greater than the end ordinate.

Sir John Biles said the paper was to some extent supplementary to a paper which the speaker had the honour of submitting to the Dominions Royal Commission. In that paper the speaker had to deal with the relation between size of ship and length of voyage in connection with the needs of the Empire for deeper draught ships; that, at any rate, was the conclusion reached. The object of the investigation, however, was to see what was desirable to be done in order to improve the efficiency of transportation. In that investigation the new point developed by Mr. Anderson was not included. Mr. Anderson had taken into account the detention in harbours, and had assumed a rate of loading for which he had given data and particulars; from those data the author had reached conclusions differing from those arrived at by the speaker in the report to the Dominions Commission. Sir John was not prepared to agree, at the moment, with Mr. Anderson, who might, however, be quite correct. He wished, however, to emphasise the desirability of doing that to which the author had called attention, *i.e.*, giving an exhaustive and careful consideration of the methods of loading ships with a view of reducing the amount of detention in port. He would just like to call attention to the value of Table I, and consider for a moment item 16, giving the days in port; that he regarded as the crux of the problem. Taking the vessel of largest size, the 11-knot vessel of 570 ft. in length, it would be seen that the calculated detention in port was 13 days, while the detention in port of the smallest vessel was about 2½ days. Sir John was not sure that he had not heard and known of vessels as large as 600 ft. long, whose detention in port regularly did not exceed one week. He could not say that they attempted to handle as large a cargo as that shown by the table; but they handled a large amount of cargo and they did it in a week. There might be doubt as to whether Mr. Anderson's conclusions could be so expanded as to arrive at the statement that 13 days in port were necessary for the unloading of one of those vessels.

He emphasised the extreme desirability of investigating from the shipowners' and the shipbuilders' points of view the question of whether much more rapid methods of loading and unloading vessels could not be achieved. He thought that there was no doubt in Mr. Anderson's mind that if a large ship could be discharged in port as rapidly as a small one, the large ship was more efficient than the small one. But unless the large ship could be discharged with sufficient rapidity to more than compensate for the disadvantages of the smaller ship, then the smaller ship might be more efficient than the larger one. He did not know whether Mr. Anderson had given consideration to the handling of cargoes other than "derrick" cargoes, such, for instance, as grain cargoes, which could be poured into a ship. If he had, some modification would be required in the author's calculations.

Mr. A. T. Wall remarked that Prof. Welch and Sir John Biles had both pointed out the valuable work done by Mr. Anderson, and he desired to endorse their opinion and to add that the work

was what was required, more especially if followed along the lines of better co-ordination amongst shipowners and shipbuilders. As the author had remarked in the first paragraph of the paper, war conditions had made the subject one of national importance. Mr. Wall was of opinion that in ships built at the present time freight rate was of smaller importance, except in so far as it indicated the uneconomical use of men, coal, and upkeep expenses. The permanent charges, such as brokerage, tonnage dues, depreciation, insurance and profit could be more or less ignored, as they did not utilise labour and material to the same extent. Certainly, the chief thing to be considered was the maximum ratio of the deadweight carried to expenditure on labour and material. The first cost of building might be taken as a good measure of the expenditure, so that the ratio of deadweight carried to first cost—the factor used in the paper—became the guiding factor. Arising out of the paper by Sir George Carter, which had been read at the morning meeting, was the curious circumstance that A and B types of standard ship, 400 ft. long, came out very favourably when examined in the light of the present paper.

Derrick Capacity.

Of course there were a number of conditions to be assumed, but so far as Mr. Wall had had time to look into the matter, that conclusion seemed fairly right. That was not the only consideration when ships were being built; the size of the slips in the shipyard had to be considered: and while it might not be so necessary to build larger ships than the most economical, smaller ships must be built to use up the smaller slips. The question of derrick capacity had entered very largely into Mr. Anderson's paper, and the derrick capacities shown as full capacity were, apparently, much above those in existence at the present time. With a small derrick capacity a large vessel would lose very much as compared with the best size, the smaller vessel not losing so much. When there was a large derrick capacity the large vessel did not lose so much compared with the best size, whereas the smaller vessel lost very rapidly; that would indicate that as terminal facilities were improved the ships would automatically increase in size. For that there would be two reasons. With increased derrick capacity the economical vessel was larger and greater sizes could be adopted without losing much economy. This led Mr. Wall to the point brought up by Prof. Welch, about the deepening of trade routes and harbour facilities running together, because increase in harbour facilities entailed increased size of ship; it was therefore necessary for them to run together. Many things could, of course, be evolved from Mr. Anderson's paper which had not been put down, doubtless owing to limitations of space. The speaker believed it would have been advantageous had some of the other curves which the author had worked out been reproduced. It was noticeable that the length was certainly variable either way within 5 per cent. of the optimum value without seriously affecting the economical result. One deduction in the paper had struck the speaker as being interesting, namely, the effect of speed on the cargo efficiency. From the curve in Fig. 11, expressing the cargo efficiency on a speed base, it would appear that for a long-voyage ship the best speed was 9½ knots. If that speed were increased to 11½ knots the cargo efficiency would only be 90 to 95 per cent., and by increasing the speed to 14 knots this efficiency would be brought down to something like 75 to 80 per cent. He regarded those figures as eloquent of the cost of increased speed.

Efficiency.

Sir William Smith desired the author to add to the value of the paper by carrying out one or two suggestions which he (the speaker) would make. He would, in the first place, like to go beyond the observation by Prof. Welch in connection with the definition of (E). All would recall, from the experience of their early days, the exactness in the definitions of Euclid; those definitions included what was necessary, leaving the mind in no doubt about the nature of the thing defined. The author's (E) impressed the speaker as a definition of what might be called the advantages of trading on one route—in comparison with another—rather than a definition of the efficiency of the particular ship. The efficiency being known, it was necessary to consider all sorts of things. At the present moment a ship might be more efficient, although she had twice the number of men, and was burning twice as much coal, so long as she could carry a cargo of munitions to a particular place by the time needed. That, of course, was not what the author had in mind. Mr. Anderson was dealing with normal conditions for general transport. So great was the power of misconception on the part of the press that Sir William was anxious, in view of the valuable work Mr. Anderson had done, that he should make some observation which would assist in removing the almost insurmountable barrier presented by misrepresentation in the papers—a difficult thing to do. The root of the matter was certainly in Mr. Anderson's paper. The author had gone into the question of the deepening of trade routes, terminal facilities, &c., but, personally, Sir William was suspicious of high and dry form, such as "This is the method of finding out this, that or the other." When dealing with such matters as square or cube root, all were agreed that the method was the right one. When more complicated matters were dealt with, a form or a formula might be adopted which, by reason of having been worked from chosen examples, gave what was known to be correct results in relation to such examples. If carried beyond those examples, however, to conditions not so far contemplated, the method would be found to give unsound results. When the speaker first went to the Admiralty, it was there thought that a great deal of wisdom was embodied in a formula which was called "the fighting capacity of ships." Certainly, there was some satisfaction in it. Particular battleships were selected, and their relative fighting capacities were arbitrarily assessed by sailors at, say, 100 per cent., 125 per cent., and 130 per cent. Naval architects were then pressed to devise a formula whereby—for the information of Parliament and the general public—the fighting capacities of ships could be assessed, so that it might be known whether value for money was being obtained. The formula was evolved and worked splendidly, so long as it was applied to one particular type of ship. With progression beyond that type the formula would not work. Sir William had been very pleased to hear the remarks of Sir John Biles, whose knowledge of the subject was superior to the speaker's. Sir John had expressed the judgment that the method was right, a point which the speaker could not determine. As he had said, however, he was suspicious, and would suggest that, as time went on, Mr. Anderson, with the skill he had exhibited in the present paper, would continually check his formulæ, and, if necessary, write another paper, based on later data, embodying the results of his revised investigation. He would also be glad if Mr. Anderson would turn over in his mind what Prof. Welch had said about the manifold aspect of the term "efficiency," and, on some future occasion, put forward something which would represent many conditions other than the simple one of relation between time on the voyage and time in port.

Dimensions and Time in Port.

Mr. Finlay remarked that the paper belonged to a type which might, with advantage, be more frequently repeated at the Institution meetings. Undoubtedly of much interest to shipbuilders, the paper might, he thought, be read with even greater profit by shipowners. When it was realised how many factors had to be taken into consideration before the dimensions of the proposed new vessel could be satisfactorily determined, it seemed scarcely credible that even now shipowners should be content to have their ships designed, in the rough at any rate, by retired sea captains and others posing as naval architects. The author had dealt impartially with the advantages and disadvantages of the large steamer generally, but the speaker did not think the balance had been quite evenly held, in respect, for instance, to the author's consideration No. 7, namely, "Greater loss in case of mishap or disaster." Against that greater loss should be set the reduced likelihood of the disaster taking place, owing to the more effective sub-division made possible, not only by the greater length itself, but also by the greater ratio of bulkhead freeboard at the draught which accompanied greater length. In this relation he would contrast the 250-ft. ship—which would certainly founder if rammed in the cargo holds—with the 570-ft. vessel, having three times the freeboard ratio and more than twice the number of bulkheads. Table I contained a great deal of interesting and valuable information, but dealt only with vessels of 11-knot speed. He would ask Mr. Anderson if he could give, in tabular form, the corresponding particulars calculated for the various ships at the speeds of 8, 9½, 12½ and 14 knots. He was sure these particulars would add considerably to the interest of an excellent and extremely readable paper.

Mr. C. I. Davidson, speaking with regard to efficiency and the time spent in harbour, said that those who had to deal with ships would know that in many cases the appliances on board a vessel had very little to do with the time that vessel was in port. He recalled the case of a vessel, of which he was the engineer, which brought grain from Smyrna to Millwall Dock, and discharged the whole cargo (some 3,000 tons) in one day. On the next voyage, with the same description of cargo, taken to Plymouth, the vessel

was in port the best part of three weeks. For that reason, he thought that the formula dealing with the time lost should be received with great caution, and it was doubtful whether fixing the length of the vessel and fixing its size in accordance with the formula was altogether correct. It appeared to the speaker that in adopting his formula for breadth the author had somewhat handicapped the long vessel, with the result that, in the case of the long vessel, at a similar speed to the short one, the length-speed ratio was very much less. Certainly, for her length the long vessel was carrying less cargo than she might if the breadth were proportional. He suggested a formula which he claimed would give a better proportion in regard both to size and speed, because the author drove his short and long vessels of the same beam at varying speeds. Obviously a vessel would not be driven at 14 knots and at 8 knots with quite the same beam. A formula such as the speaker suggested would give a narrower vessel at the higher speeds, and, if that were done, the great drop in efficiency at the rather higher speeds would be varied considerably. Mr. Anderson had stated that 8 knots was the most efficient speed. Eight knots was certainly a very good speed when attained, but those having to do with ships knew that an 8-knot vessel rapidly dropped her average with very little bad weather. Turning to Table I in the paper, Mr. Anderson had, apparently, assumed that the percentage of erections on the vessel would be the same in all cases. The amount of erections on a vessel was a recognised method of strengthening the longer ship; and, on coming to the drop of the curve, was it needful to accept that as complete, or might not use be made of other methods, enabling the efficiency to be maintained? Referring to items 20 and 30 in that table, the speaker had roughed out certain data in regard to the 490-ft. vessel. If the amount of erections were increased to make her a complete shelter deck vessel, the increased free-board would allow the displacement to be increased to about 4½ to 5 per cent., which would necessitate 3 per cent. more engine power. But the net deadweight would be increased about 6 per cent. Taking those facts into consideration, with a moderate increase in the cost of the vessel, keeping her under £8 per ton, the gross deadweight cargo transported per annum could be brought up to 1·78 and the rate per ton brought down to just a fraction over 8s. In adopting any tabular system, in regard to beam and other data, care should be taken to guard against undue handicapping at the extreme ends of the curve.

Cost *v.* Cargo Capacity.

Mr. Robb criticised the paper as to the fundamental assumptions of the investigation. In the second paragraph it was stated that the ultimate object of all interested in shipping was that the vessels engaged should transport the maximum amount of cargo in relation to their initial cost, and at the cheapest possible freight rate. The speaker would like Mr. Anderson to amplify that statement, since it seemed questionable whether the maximum amount of cargo, in relation to initial cost, had any real bearing on the subject. Was it not the measure of a vessel's efficiency that she should transport her cargo at the lowest freight rate? He believed, for example, it had been argued that the transportation of the maximum amount of cargo in relation to the initial cost was of considerable importance in the present circumstances, when the money-earning power of ships was not of vital importance. It seemed reasonable to point out that freight rate was not looked upon as a measure of the earning capacity of a ship in itself, but, after all, it was a measure of the work done in transporting the cargo. If the amount of cargo carried in relation to initial cost were measured, that would only be measuring the amount of work done in building the boat, the amount of work done after the boat was built being left out of account. It seemed to him that the thing that mattered was not the efficiency but the freight rate, and that alone should be the measure for investigation. As a matter of fact, he was aware that the difference between the results which might be got by measuring the qualities of the ship according to the author's method and measuring them entirely on a freight rate basis would probably be small. He would much like Mr. Anderson to deal more fully, however, with that point.

He further asked the author if he had any idea of what would be the effect of varying proportions of the different charges on the ship. What, for instance, would be the effect of the hull cost, or the insurance cost, going up in a greater degree than the discharging cost; in short, of one element going down while others were going up? He would be glad if Mr. Anderson would indicate what might happen when possible variations of the different factors were taken into consideration.

Special Routes.

Mr. T. A. Johnson said that from the particulars given, he presumed that the author, in drawing up his paper had worked on data obtained from ships designed for a special route. He would take as an example the Blue Anchor Line, or a ship of that type; a ship running on a definite route and designed not necessarily for a special cargo, but for conditions which were pretty well known. If the speaker were not correct in this view, there were one or two cases, not raised in the paper, which needed consideration. If, for instance, the paper and the definitions in it were taken as an absolute criterion or test of the most efficient type of ship, it became problematical why so many ships were built of a length of about 300 ft., and a total deadweight of rather under 4,000 tons. That was a matter which, when more intimately concerned with that type of ship, he could never understand. It had always seemed to the speaker that such a ship was too small for economical management. The real fact was that that type of ship was built as a pure and simple "tramp," and not as a boat running to and fro on a definite route. It would, for example, take coal to the River Plate and mixed cargoes to the States, returning with cotton or grain. One reason why the type was so economical and so largely adopted was because more regular dependence could be placed on getting a cargo of 4,000 tons deadweight on a charter at those ports than when the ship was larger. That had to be borne in mind, because a shipbuilder might get hold of the data, and say "There is the way to fix on the best type of ship." When looked into, however, he would find it was not so. There was justification for the small type. On the other hand, in the case of the large ore and grain carriers on the Great Lakes, where 11,000 or 12,000 tons of ore could be loaded inside of an hour and discharged in four or five hours, the most efficient type of ship was the one with a large deadweight capacity and the comparatively high speed of about 12 knots. The speaker had been particularly desirous of raising these two points, because he felt that they ought to be borne in mind in any consideration of the paper.

Mr. Anderson's Reply.

Mr. Anderson then replied briefly to the discussion, expressing his gratification at the kind remarks that had been made in connection with the notes which he had put together. He thought that it might be desirable to add something further to the definition of "efficiency" he had given, as suggested by Prof. Welch and Sir William Smith, and he would give the point consideration. In regard to the remarks of Sir John Biles, the speaker's notes were a development of the views set forth by Sir John in the paper which the latter had read in 1900, and in connection with that paper it would be noticed that Sir John had specially qualified his remarks, and that he did not cover certain factors in relation to the cost of handling cargo. He had considered the effect of loading and discharging grain cargoes for one or two ships, and on trial it seemed to him that so long as the time in port was measured as against the total time, the method was fairly correct. With regard to Mr. Davidson's remarks, Mr. Anderson agreed that the breadths he had stated in the paper did not correspond with present-day practice. He had figured on a speed of 9½ knots as being the most economical for the general trader, but he could not quite understand that a vessel which was wanted for particularly heavy weather would, perhaps, be benefited by a greater speed. Mr. Davidson had also remarked upon the variation in the erections, but in his paper he had made a general remark to the effect that if one vessel with similar erections were compared with another, he thought the lengths would hold good; Mr. Davidson, therefore, was making a change in the arrangements upon which the speaker had been working; some correction would have to be made for that. He agreed with Mr. Robb's view that, in normal times, freight rate would be a limiting factor, but he would point out to Mr. Robb that he was dealing with the case of detention as well as the actual freight rate, and it was for that reason he had selected the spot in between the results. As a matter of fact, for boats up to about 11 knots, and with efficiencies of about 0·55 per cent., there would be only about 10 to 15 ft. of difference between "tons carried" and freight rate cargo. The 5 per cent. suggested by Mr. Wall would cover any differences of that sort. Mr. Anderson had considered the effects of variations in insurance and other costs, and if those figures should be less than he had stated, there would be a slight increase in the length of the ship, but it would not be of very great magnitude. In reply, to Mr. Johnson's observations as to the 300-ft. vessel being the most suitable for a "tramp" trader, he would say that that appeared to him to be a

question of the trade in which the vessel would generally be engaged. If a vessel somewhere between 360 ft. and 400 ft. had been found the most suitable for the general cargo tramp, that was justification for the selection of dimensions between those limits.

Mr. Abell's paper on "Problems in the Design and Construction of Ships" (p. 342) and Mr. Seaton's paper were discussed together.

SOME NOTES ON THE IMPORTANCE OF RESEARCH IN MARINE ENGINEERING.

By A. E. Seaton.

The author in this paper urged the importance of systematic research and cited a number of failures and successes in marine engineering to illustrate the negative and positive sides of the question. He also recalled how a shipowner once complained to him of the extravagance of his superintendent engineer in spending £700 in one year on experiments which had been mostly failures. His advice to the owner was to let the superintendent spend much more, for, seeing there were 70 steamers under his supervision, it was more important for him to discover what things were wrong to have on shipboard and avoid them, even than to ascertain those which were good. He could generally find out all about the latter without troubling himself to make special experiments.

The object of the paper was to concentrate attention on research work as being not only necessary and interesting, but really remunerative in results and of great benefit both to the individual and to the public at large, and to show that it may be so even when the results are negative in character. Further, to ensure that, in future, research work shall not be left entirely to unaided and individual effort, or even to the collective effort which in the past has been only too often unmethodical and sporadic because unguided. To avoid this there must be found the means, the men, and the machinery for the following objects:—

(1) Individual efforts and enterprise shall be encouraged, and when found to be in the right direction, they may be assisted so as to be carried to a successful issue without loss of time.

(2) All individual efforts shall be as far as possible co-ordinated and combined, so that by united action higher efficiency and quicker development in practical results may be attained in solving each problem dealt with at the least cost.

(3) Definite and systematic study of each and every proposition that the marine engineer is faced with should be made in such a way as to be free from all personal prejudice or interest, and its development be proceeded with.

(4) To study the possibilities of every project with a view to the public good, so that inventions, or even mere ideas, when proposed may be examined with care, and tested by means which are wanting to the originators, whereby they may be dealt with adequately.

(5) To examine afresh many of the accepted axioms, aphorisms, and formulæ which now pass muster for use in marine engineering, in the light provided by modern knowledge, and by methods found successful in later years, in order to prove if they have been established and still remain on sure foundations or otherwise.

(6) To examine afresh the proposals and ideas contained in the old patent and other records with a view to winnowing from them the seeds of things which may now be cultivated and made to produce fruit, but which, when they were first proposed, could not be done from want of the means of manufacture.

If research can accomplish these things, it will amply repay any reasonable sum spent on it.

The author suggests that a committee such as the British Marine Engineering Design and Construction Committee, of which he was chairman, would be a very suitable one for administrative purposes in research, consisting as it does of members of every branch of the marine engineering profession, selected by the various institutions interested in marine engineering progress, and having on it also representatives of such bodies as the Board of Trade, Lloyd's Register, the Bureau Veritas, and British Corporation. To them might be added with great advantage, representatives of the Admiralty, the Indian and Colonial Governments. A suitable staff with a director at its head would also be necessary.

An important Government Department was constituted in 1915 under the title of "The Committee of the Privy Council for Scientific and Industrial Research." It is assisted by an Advisory Council as well as by Standing Committees on engineering, metallurgy, mining, and other applied sciences. A fund of £1,000,000 has been placed by the Government at the disposal of the Research Department to encourage British industries and to undertake research work generally, but so far he was not aware that any of it was earmarked or otherwise reserved for any undertaking that may be considered as marine engineering, notwithstanding that the importance of this branch of industry to British and Colonial maritime interests should entitle it to a considerable share of such a grant.

It appears, however, that it is proposed that certain bodies or associations in various localities, representative of the local industries, shall co-operate with the Council of Research, and that the cost of such research work as may be undertaken in this way shall be partly defrayed from funds subscribed locally by parties interested in the results and partly by grants from the Government Fund equal in amount to the subscriptions. In this way marine engineering may possibly come in for recognition.

The Engineering Committee referred to above have furnished a list of subjects thought to be suitable for immediate research in marine engineering.

In the course of the discussion Sir Philip Watts said that although he did not agree with every point made in Mr. Abell's paper, he was in favour of some of his proposals with regard to large scale trials, especially as to resistance and other problems. We should gain appreciably by a closer study of the performances of merchant vessels on service probably in conjunction with model tank experiments. The investigation of various work processes would also have to come under review. Power had always been cheaper than labour, and we should endeavour to educate the workman to become a director of labour rather than to continue to look to his own efforts as an individual.

The Need for Passenger Ships.

Mr. L. Peskett, of the Cunard Steamship Company, said Mr. Abell stated the question of the particular type of ship that would ultimately be of the greatest service to the country which should be fully discussed by those well acquainted with the passenger and cargo trades of the world and their recommendations carefully considered. The necessity of building 5,000 to 10,000 tons d.w. cargo ships was fully recognised; at the same time, having in mind the great losses that were occurring among the passenger-carrying fleets of this country through the action of enemy submarines, the post-war repatriation of troops, and the necessity of maintaining our position in the passenger-carrying trade of the world, some consideration should be given to the building of partially standardised intermediate steamers that would be capable of carrying a large number of passengers in addition to a very large cargo. Ships built for this purpose need not be delayed in construction to fit all the equipment necessary for the conveyance of passengers it was ultimately intended to carry—only such parts of the general equipment being fitted that would cause no delay in the structural steel and machinery. As soon as the vessel was at the stage suitable for freight carrying she could proceed to sea, and the remainder of the passenger accommodation finished at convenient times when the ship was in port discharging cargo and bunkering. At the present time the building of ships that could at the end of the war be converted into passenger vessels was forbidden; if such conditions were allowed to continue the country would not at the close of hostilities be in a position to take the foremost place in the ocean passenger trades of the world. Steamship owners who by their own enterprise in the past had brought to a high standard a class of vessel that had won for this country the supremacy of the sea should be given a reasonable opportunity to maintain it. There was a certain class of intermediate steamer that would suit several trades, and there appeared to be no reason why shipowners interested in a particular class of ship should not agree to build a series of vessels of similar dimensions, power and speed, and in that way standardise much that had to be done in the construction of hull and machinery.

In speaking of the economy of ship operation, Mr. Abell had drawn attention to the necessity of having further information from the actual results obtained from ships that had made several voyages, the lines of which had been developed from the best results obtained from a set of forms tested in an experimental tank. A lot of useful information might be gathered from data in the possession of shipowners, many of whom have had ships of similar dimensions, power and capacity, built in different yards with no two sets of lines alike. An analysis of the factors that determined the value of the ship as a commercial asset, taken from the logs and accounts extending over a period of several voyages, would be of immense value for future guidance in design. In connection with the question of sub-

division Mr. Abell stated that the introduction of the new regulations on subdivision of passenger steamers had been deferred for a time. The general opinion among shipowners was that the enforcement of any new rules should be deferred until a close investigation had been made of the types of vessels that had been torpedoed and sunk during the war. In many cases well subdivided ships had gone under, while ships with ordinary subdivision that had been damaged by mine or torpedoes had reached harbour. Such results made it desirable that the laws regarding subdivision should be held in abeyance until such investigation had been made. The new Board of Trade rules on subdivision were not International, and their enforcement might in some cases retard progress. It would appear from general reports on ships that had been torpedoed that most had gone down by the head or by the stern, which would indicate that better subdivision, or bulkheads carried higher, at the ends of the ship, or as a substitute, rapid means of flooding the holds at the ends of the ship, by which means it would be possible when a vessel was torpedoed at one end, it would be possible by flooding the other end to bring the vessel to somewhere near an even keel, and although there would be a considerable increase in displacement, and a reduction in the amount of stability, there would be a possible chance of saving the ship. Attention had been drawn to the desirability of building the intermediate or mixed type of steamer.

Intermediate Liners.

A ship of this class was penalised in the matter of cargo handling facilities. When the vessel was subdivided in accordance with the curves devised by the Bulkhead Committee, and the number of boats under davits on each side placed in position, there was very little space left between the sets of davits, consequently the length of hatchways was limited. Short hatchways meant delay in the handling of cargo; more especially was this the case if the vessel were intended to be up-to-date, and fitted with double reduction geared turbines, and water-tube boilers with oil fuel. Such a ship would carry the fuel in the double bottom and at sides of tunnels, an arrangement which would provide for an additional cargo hold, as compared with a vessel fitted with cylindrical boilers with coal fuel. A ship of 580 ft. in length fitted with water-tube boilers fired with oil fuel, designed to carry 520 cabin passengers and 1,700 third-class passengers, and a total deadweight of about 13,100 tons, would be a valuable asset at the close of the war. There would be a saving in the number of men required for engineers' staff, and there would be a considerable increase in the cargo capacity as compared with a ship of the same dimensions but having an installation of Scotch boilers with coal fuel. A reduction in the number of boats carried under davits on each side, but having on board flotation for all in the shape of easily handled rafts, &c., would admit of an increase in the length of some of the hatchways; this in turn would facilitate the speed of loading and discharging, and consequently a quicker turn round in port and a larger number of voyages made in a given period. Such a ship would economise in men, provisions, and fuel, and would carry an additional quantity of cargo, results which were much to be desired. The economy of material was a subject requiring careful consideration before any appreciable alteration could be made. Ships of ordinary types built to the rules of one of the Classification Societies were difficult to improve upon. The scantlings were the result of a combination of laborious calculation and many years of experience, and had proved very efficient, although additional thicknesses might be added to some parts of the structure in cases where owners had been taught by experience to make provision for the special circumstances of particular trades.

Double Bottoms.

The cellular double bottom appeared to be the only part of the structure where reductions might be made, but it must be borne in mind that this part of the vessel, owing to inaccessibility, was more liable to corrosion than the upper structure. Other causes, including the occasional need of putting a ship in dry dock with a considerable amount of cargo and coal on board, made it imperative that this particular part of the vessel should be of greater strength than that demanded by the results of calculation which did not always provide for the unknown stresses that came upon various members of the structure when the vessel was corkscrewing in a heavy sea. One of the most important factors in the design of an Atlantic passenger ship was that of providing "boats for all." It appeared, however, on examining the reports of some recent disasters, and bearing in mind the complication of the upperstructure of a modern Atlantic liner when fully equipped with boats for all, that we had not yet arrived at the best solution of the probl m. It was questionable whether lighter forms of life-saving appliances would not be preferable, and certainly more lives would have been saved than was the case had some of the recently torpedoed vessels been provided with a proportion of easily handled rafts or some other equally buoyant apparatus.

Professor W. E. Dalby, F.R.S., said that the Council of the Institution of Naval Architects had been more sympathetic in the matter of scientific research than any similar body with which he was connected, and he specially instanced the occasion when he had told Sir Alfred Yarrow that he could balance a torepdo boat without any experiments at all. In most cases he would have been turned down, but Sir Alfred listened to him, and was willing to be shown how it could be done. Mr. Seaton's paper was a brilliant and valuable summary and exhibited a profound knowledge of what might almost be called a century of invention. The crux of the whole matter was, however, that capital was necessary to develop an invention.

Progressive Trial Results.

Sir William Rowan Thomson agreed with Mr. Peskett that there was an undoubted difficulty in getting really reliable data from owners' logs as to trial trips and that in the main was due to the large amount of clerical work which was involved. So far there had not been much success in arousing shipowners to the importance of devoting care and attention to getting accurate sea results. In referring to the necessity for the liner type of vessel, he presumed Mr. Peskett was referring to present conditions, because he must be aware that a liner type was at present being built and one which he had no doubt could easily be adapted to carrying passengers later on. The necessity for collaboration in design on the part of owners was one of the first and most real difficulties with which shipbuilders and engineers had to battle. The great deal of minute variation in requirements of individual builders led to a tremendous amount of unnecessary variety in the construction of ordinary cargo vessels and in the machinery, and it was not only desirable but absolutely necessary that there should be collaboration between owners if there was to be bulk production. This collaboration should include unification of design which was essential to speedy production and an agreement on the part of all concerned that while they might differ as to minute details or even the larger parts, yet a particular item might be quite good for its purpose. If that was so, there was no necessity to make it more complex. He was exceedingly pleased to see in print the statement in Professor Abell's paper that increased output was only possible by the joint effort of employer and workman and by a joint increase of remuneration for both parties concerned. Failure to recognise that fundamental fact had been the cause of many labour disputes. He did not think individual research by firms would ever become the general practice because the cost of research was apt to grow to such proportions as to be a very serious item in the costs of any particular firm. It was far better carried out by institutions established for the purpose supported by the industry concerned.

Mr. E. L. Orde agreed that the necessity for research was one of the most burning questions of the day. No single firm could carry out the suggested full-size experiments on skin friction of cargo steamers, and in his opinion the little sporadic efforts at research on the part of individual firms did nothing to add to the sum of common knowledge of industry. Therefore, research, if it was to be carried out, should be a charge on industry, and secondly, it should be confined in its operation to the trades with which it was most intimately connected.

Mr. D. B. Morison said the North-East Coast Institution had made a departure and was willing to investigate apparatus approved by the Council and to report thereon for the benefit of its members and of engineering in general. A very complete investigation had already been made upon a subject about which much confusion existed a few years ago and about which many false doctrines were preached. The report of the investigators had now been issued and contained the results of over 250 tests and much valuable data. Further experiments were now being made with other apparatus used on shipboard. Tests had already demonstrated the possibility of saving about half the quantity of brass, much weight, much labour and much money. These were not speculative results but actual, and showed what could be done even now by our institutions with national aid. Reference had been made by Mr. Seaton to the work of the Committee on British marine engineering design. He himself was a member of the Grand

Committee, not of the working committee; therefore he could freely offer some remarks on the matter. The Committee was the outcome of a paper which he read before the Institution last year and it represented a co-ordination of various committees of various institutions. He wished to emphasise the fact that if the committee succeeded in one of its objects, viz., to codify the rules for the construction of marine boilers, it would have achieved one of the greatest works presented to engineering in modern times, and if that was achieved, he again said it would be due to the chairman, Mr. Seaton.

Mr. Hamilton Gibson referring to the first group of suggested subjects in Mr. Seaton's paper said he had very little faith in the application of roller or ball bearings to marine engines. After what he had seen of the the marvellous persistence of the oil film as applied to thrust and journal bearings, he was convinced that engines could be made to run practically frictionless with loads which would break down roller or ball bearings. He would like to see added to this group an investigation of the actual propulsive effect of propellers. That was now quite within the region of possibility, and we should be able to obtain some valuable and perhaps startling results in comparison with the torsion meter results mentioned in item (*b*) in the same group. The accuracy of torsion meters required further experiment because at present on a movement of $\frac{1}{4}$ inch the torsion meter had to record variations of horse power from zero up to 30,000 to 40,000 h.p. Furthermore, it had to be remembered that in employing multiplying gear, this multiplied not only the torque of the shaft but any error that might exist. In group 2 in the paper the important item of effective water circulation in boilers was omitted. As the equalisation of temperature, especially when raising steam, conduced to the tightness and durability of the boiler, he suggested that item should be considered. The final item in Group 4, insulating materials, happened to be a subject of investigation of the Liverpool Engineering Society. That body would, of course, keep in touch with the other societies engaged in similar or allied branches of research in order to prevent overlapping and with a view to co-ordinate the results.

Model Experiments.

Mr. G. S. Baker superintendent of the experimental tank at the National Physical Laboratory said the particular items which interested him were mentioned in Professor Abell's paper, although one, viz., propulsion by screw propellers, was mentioned by Mr. Seaton. The longer one studied things the more one was convinced of the need for further research, but although during the past three or four years four papers had been read before various institutions suggesting large scale experiments in connection with skin friction resistance, so far as he knew nothing had been done. The fact that such a thing was required was known to all who had to work with skin friction or do anything in connection with estimating the horsepower for ships and he hoped that such experiments would be made. On the question of trial results and analyses, those connected with the experimental tank had undertaken on several occasions to analyse ship-trial results for shipowners and occasionally for shipbuilders, but they had been handicapped very considerably in doing such work by the fact that they could not get all the data they wanted. He did not know whether that was due to a fact that had been mentioned, viz., that shipowners abhorred clerical work, yet the fact remained that very few ship trials were conducted in a proper scientific way. He had read every paper that had been presented to the Institution since 1860, every paper that had been read before any English society and most of those before American societies, and he had not found one printed in England with sufficient scientific data in it to enable a complete analysis of the results to be made. Four or five in America had been good and that was all. If these trials were conducted properly a great deal of information would be obtained. They were prepared at the tank to save the owner and the builder all the work involved in taking these trials or in obtaining the data by sending their own staff to collect it and analyse it whenever they could be provided with actual experimental data or where they themselves had the data.

Professor Welch said that one or two matters mentioned by Professor Abell were about to be raised at the beginning of the war. A kindred institution had appointed a committee to deal with the standardisation of ships' fittings. That committee had been asked to report as to the articles best suited for standardisation, and he hoped that effective action would be taken on their report. With regard to research scholarships, the latest holder of the research scholarship of the Institution, Mr. E. L. Champness, of Armstrong College, had intended to carry out investigations abroad on shipbuilding practice. He had, however, been engaged since in important war work, but he hoped to be able yet to carry out his original intention. He agreed that such an investigation would be of considerable value to industry. For the suggested research on stability at sea, he presumed Professor Abell intended to have expert observers as the ship's officers would have no time to ensure accurate results. One and two compartment ships were referred to in the paper, but these terms were not used by the Bulkhead Committee because it was thought that in popular use it might be very easy to forget what a one or a two compartment ship really was. A ship was a one-compartment ship under a certain assumed permeability which might or might not be obtained on a particular voyage.

Mr. W. Millar said he had advocated longitudinal bottoms many years ago, but the idea had been turned down. In his opinion, however, if there was any waste in a ship it was in the double bottom. Everybody was crying out to save waste of material, yet this waste went on. At the present moment he had five ships under construction with longitudinal bottoms, transverse framing and longitudinal decks and considerable savings had been effected. He invited them to visit Greenock in order to see what could be done in this way.

Professor Abell indicated his desire to reply in writing owing to his having a bad cold.

The fifth paper read was the

EFFECT OF THE LONGITUDINAL MOTION OF A SHIP ON ITS STATICAL TRANSVERSE STABILITY.

By G. S. Baker and Miss E. M. Keary.

The authors point out that it has been known for many years that the distribution of forces around a ship when in motion is different from that when at rest. A little consideration makes it clear, therefore, that the stability when in motion may be different from that when at rest, and that the difference may become important as speed is increased. The object of the experiments outlined was to measure this effect on some typical forms, and, if possible, to determine when and why it becomes important.

The results of the experiments have been analysed only so far as to give precise data for the individual forms concerned. When more models have been tested and circumstances allow of more time being devoted to the subject, the analysis will be carried farther, so that results may be predicted for any given form. From what has been done, however, certain general conclusions are evident, viz. :—

1. For all vessels there is a systematic variation of stability with speed.

2. This variation is never important unless the wave-making resistance is important.

3. In ordinary tramp steamers and low-speed mercantile vessels a small loss of metacentric height, not exceeding 5 in., may be obtained.

4. With higher speeds—within range of many existing vessels (besides destroyers)—variation in metacentric height of from + 3 in. to − 2·3 in. have been obtained with quite normal forms of different type, and these must be regarded as quite possible variations for forms capable of running at speeds between $\left(\frac{P}{\ }\right)$ = 1·0 and 1·5.

5. At still higher speeds, *i.e.*, above $\left(\frac{P}{\ }\right)$ = 1·5, and before a vessel begins to plane or skim, it suffers from considerable loss of stability due mainly to the bad action of the step and the after end being partially under water on the immersed side.

6. Destroyers which work in the speed range covered by (5) suffer from this same loss of stability.

7. When a vessel is planing with the chines and step running quite clean, it can derive a large amount of stability from the action of its planing surfaces.

8. In all the models tried the variation of metacentre is, roughly speaking, independent of the transverse inclination of the form within the experimental limits of inclination, viz., 7° to 9° maximum at rest.

9. The movement of the metacentre is not proportional to the square of the speed.

Of these conclusions, No. 4 has the greatest practical importance, but Nos. 2 and 8 have a greater bearing on the study of the phenomena. These show that the effect is set up by the longitudinal motion alone, that it is not brought on by the transverse inclination, but exists when the ship is at any angle, including the upright position.

The fifth paper was:

THE IRON CARBON EQUILIBRIUM DIAGRAM AND ITS PRACTICAL USEFULNESS.

By Prof. H. C. H. Carpenter, M.A.

The paper has been written with a twofold aim:

1. To show briefly how the temperature concentration or equilibrium diagram has been constructed; and
2. To illustrate its practical usefulness to the engineer.

The thermal equilibrium diagram of a binary alloy whose coordinates are temperature and concentration shows graphically and at a glance exactly what constituents or phases, are present in the alloy at any given temperature and for any particular concentration when the system is in thermal equilibrium. It also shows the range of composition and of temperature over which a particular constituent can exist. It shows further the boundary surfaces between the various phases, whether they are vertical, horizontal or sloping.

This diagram can be established in any given case by suitable experiments, and these fall under two general heads: (1) by the use of the method of thermal analysis, and (2) by the study of the structure after the alloy has been treated so as to bring it into thermal equilibrium at the temperature in question. The former requires the use of high temperature thermometers or pyrometers, and involves the taking of heating and cooling curves; the latter demands the preparation of the alloys for microscopical examination. The function of the former is to detect the thermal change which occurs either on heating or cooling; that of the latter is to interpret what the change is.

The components of any system are the pure metals. The phases are the homogeneous portions of the system which are separated from each other in space by bounding surfaces.

The author then considered in detail what takes place when certain typical steels are cooled from the liquid conditions, viz., pure iron, mild steel, medium hard steel, hard steel and tool steel, and in conclusion gave some practical uses of the equilibrium diagram as affecting the operations of annealing, hardening, tempering and toughening, and hot rolling.

The sixth paper was:

STRESS DISTRIBUTION IN BOLTS AND NUTS.

By C. E. Stromeyer.

The author points out the desirability of being able to compare the merits of the coarse and fine screw-thread standards, and because modification in the several standards might materially improve them, both as regards strength, reliability, and usefulness.

It was felt that the thread pitches of the bolt and nut would not always be exactly the same; the result is most interesting, the shearing stress at the bottom of the nut being very much greater than at the top, these shearing stresses combine with the tension stress in the bolt, and there would be a relatively severe resultant stress at the bottom level of the nut, the very point where the stresses should be reduced to a minimum.

If the nut has a finer thread pitch than the bolt, this very severe stress would be situated at the bottom level of the nut, and would cause cracks, fractures, or stripping of threads.

This conclusion was confirmed by the failure of several successive piston rods of some large horizontal gas engines. The rods were 12 in. diameter and hollow. The screwed part was 11 in. diameter, pitch four threads per inch. Several of these rods had broken just inside the nut, others stripped their threads. Of one, its nut thread pitch was 1/1000 finer than that of the rod. The gas pressure and the inertia stresses in the rod were estimated to be about 2½ tons, but according to the present estimate, the maximum stresses under the roots of the threads would be about ten times greater, or about 25 tons per square inch. No wonder that the threads gave way!

Some main-bearing bolts had failed frequently almost as soon as they were renewed. They were not subjected to excessive loads, and the metal (steel) was found to be quite satisfactory. Subsequently, in view of the above-mentioned experience, the threads of one fractured bolt and its nut were compared, when it was found that the nut thread, a fairly coarse one, was 4/1000 finer than the bolt thread pitch. In this case my estimate was that the stresses under the roots of the threads exceeded 30 tons.

In case of future failures it would be very desirable to ascertain whether there is a difference of thread pitch. For ordinary practice in which the pitches and the thread shapes are supposed to be alike, coarse bolts similar to the Whitworth practice for 1-in. bolts are associated with lower stresses than the Seller bolts of the same proportions, the ratio of the estimated stresses being as 3·08 to 4·07. A change to medium fine pitches hardly reduces the stresses, and very fine ones (32 per core diameter) actually increase them, although the stress in the body of the bolt is reduced from 1·56 to 1·13 by the adoption of the finer pitch.

If, by chance, the nut thread pitch is finer than that of the bolt, then the Whitworth bolts improve their position still more. If they are coarser than the bolt threads, the improvement is shared by all screws. This improvement is very marked, except with the very fine threads, which hardly improve. In all these cases the maximum stress is transferred from the bottom of the nut, where it is dangerous, to the top, where even if a thread should strip, there are others to take its place. By this change, the above-mentioned stress of 3·08 at the bottom of a Whitworth bolt is reduced to 1·74, while the stress at the top does not rise above 2·16. For very fine threads the relative stresses are 3·34 for equal pitches, and 1·15 and 2·73 for the unequal ones. For Seller's threads they are 4·07, 1·76, and 3·21.

Another point in favour of relatively coarser pitch of nut thread than bolt thread is associated with the tendency to slack back. With equal pitches for bolt and nut the maximum pressure will be at the bottom of the nut, and will probably produce a kink, which, if vibrations occur, will hammer against the bottom nut thread and start a slacking back process. If the nut thread be made coarser than the bolt thread the kink will be at the top, and instead of starting a slacking back process it opposes it, even if started.

Thread angles have the advantage that their elasticity leads to a relatively uniform stress distribution over the height of the nut. The advantage of heavy truncations, as in the Thury standard, in which the roots of the threads are very wide, is that the very intense stresses under these roots are spread out over a relatively large area, and are thereby reduced.

A seriously disturbing factor is the difficulty on the part of manufacturers to make the thread shapes perfectly correct. It is, therefore, a common occurrence for the nut thread to have either a finer form than that of the bolt, in which its crest will be resting close to the root of the bolt thread, which is a very favourable condition, or it may happen that the nut thread is of a relatively blunt form; possibly, too, it may by accident be tilted upwards—worn-out nut—then its root will bear on the crest of the bolt thread, and the stresses will be two and three times severer than in the last case.

As these misfits are of constant occurrence, engineers have to provide against these worst cases by using relatively large bolts. A great improvement should be possible by using the Seller slope of 30 deg. for the bolt thread and the Whitworth slope of 27½ deg. for the nut thread, for then the errors would have to exceed 1¼ deg. before improper loading occurs.

On Friday morning papers on Concrete Ship Construction were discussed. That by Major Denny will be found on page 350. The other two were:

REINFORCED CONCRETE VESSELS.

By Walter Pollock.

In this paper, the author, who has spent much time studying the subject from a practical standpoint, puts forward some notes on the subject. He discusses more particularly vessels of 300 tons, 500 tons and 1,000 tons d.w. He considers that the prime cost of the finished concrete work, for an ordinary vessel with ship-shaped lines, at the present time should average £8 15s. per ton, on the basis of a 300-ton coaster and for the first vessel only. A saving of £1 5s. might be effected if the lines of the vessel were modified. Taking the hull complete with the requisite steel at £11 15s. per ton, concrete vessels of the same deadweight should, if standardised, be constructed at 20 per cent. less cost than a steel vessel, and 10 per cent. less cost than a wooden vessel. With a yard in proper working order, a coaster of this size should, with three berths going, be turned out every sixteen weeks.

ON THE DESIGN AND CONSTRUCTION OF SELF-PROPELLED REINFORCED CONCRETE SEA-GOING CARGO STEAMERS, NOW BUILDING IN GREAT BRITAIN.

By T. G. Owens Thurston.

In this contribution the author gave some particulars of concrete ships building at Barrow-in-Furness. These have the following dimensions :—

Length b.p....	205 ft.
Breadth, moulded...	32 ft.
Depth, moulded	19 ft. 6 in.
Draught, loaded	15 ft. 6 in.
D.w. capacity	1,150 tons.
I.H.P. (about)	400.
Speed	7½ knots.

The author discussed the means adopted to give the necessary strength and rigidity to the vessels. The weight of steel in the ships is about 42·5 per cent. of that in a steel ship, although actual service conditions may demonstrate that some saving may be effected. Three of the vessels have compound surface condensing engines of 350-400 i.h.p. and two cylindrical boilers 9 ft. 6 in. in diameter, by 9 ft. long, working at 130 lb. It is intended to install triple-expansion engines of about 500 h.p. in the other three ships. These will reduce the deadweight carrying capacity somewhat, but give an appreciable increase in speed. The machinery is fitted aft.

We hope to deal more fully with these two papers in the near future.

Discussion.

Mr. J. Foster King said that reinforced concrete as a shipbuilding material for sea-going ships was probably the most interesting practical subject of the day to naval architects because abnormal conditions had permitted it to pass from the stage of tentative experiment to that of production on a large scale and that very properly without waiting for the normal life-long period of "the other man's experience." The papers were therefore useful in the most absolute sense because they presented a broad review of the situation as it appeared to one having exceptional opportunities and ability to evaluate its technical aspects, and they gave naval architects an early opportunity of discussing an unfamiliar method of shipbuilding with engineers who know the material but were unfamiliar with shipbuilding. A good deal had been said about the need for future research in connection with structural problems, but the fact that a large volume of building with material which was practically untried under sea-going conditions was being undertaken upon the basis of research as distinguished from experience seemed to show that they had not been altogether idle in the past. All the same, as was clearly indicated by Major Denny, there were important questions which would only be definitely answered by experience, and people, like himself, who had expressed the opinion that existing data justified the experiment as one having reasonable prospects of success would have more confidence in their judgment if the present discussion had the effect of resolving certain doubts. These doubts were really due to differences in the angle from which the common problem was approached by shipbuilders and designers of land structures. The former knew with reasonable accuracy the disposition of material and methods of stress assessment that would produce a watertight sea-going steel girder which was reasonably fit to carry safely dry and perishable cargoes, itself and its crew, under all ordinary conditions of service; he had also a working knowledge of how much or how little material he had to spare for meeting stresses which act in all directions. The other knew, with perhaps more accuracy, the disposition of material and methods of stress assessment that would produce such non-watertight concrete girders, reinforced with relatively small quantities of steel as would safely carry on land loads which had fairly definite effects. When one met the other a measure of doubt had always been caused by the fact that certain questions inevitably produced the statement that reinforced concrete was not "a mere juxtaposition of concrete and steel"—it was a new material, and by inference it would do successfully certain things which did not seem naturally to come within the range of its powers. It appeared that mutual understanding would be advanced if reinforced concrete engineers would state clearly what were or were not the mechanical qualities of the material, and what were the practical results directly explicable by these qualities. The following list of properties of what Major Denny described as suitable reinforced concrete had therefore been compiled from the latest information submitted and a review of its correctness appeared to be essential to progress. Good concrete was almost uniformly elastic up to the point of fracture; it should be watertight up to the point of fracture; it might be safely estimated to have a tensile strength of at least 300 lb. per sq. in.; it usually had a compressive strength about ten times as great as its tensile strength; its tensile strength was a fair measure of its shear strength; good concrete reinforced by steel rods properly arranged and having a small area in proportion to the area of the concrete, would bind the steel under a pressure which might be over 200 lb. per sq. in. of steel surface; under the above conditions the binding effect of concrete upon a length of rod corresponding to 30 to 40 diameters was equal to the tensile strength of the rod; although the tensile strength of concrete was only 1 per cent., the elastic modulus of concrete was 8 per cent. of that of steel; reinforcement did not alter the relationship between the above moduli; reinforcement did alter the stress at which fracture occurred in the concrete, although it might not alter the stress at which fracture would occur outside the influence of its own bond upon the steel. Evidence of molecular disturbance seemed to occur at the breaking stress of the concrete, but actual fracture was delayed until the stress was about 45 per cent. greater; the elastic modulus of reinforced concrete was the same as that of plain concrete, 8 per cent. of steel; and the maximum strain upon reinforcement could not therefore exceed that due to a stress of 5,400 lb. per sq. in. if fractures in concrete were to be avoided. Turning to the technical aspect of the practical use of reinforced concrete, the points of view of shipbuilder and reinforced concrete builder were somewhat different. When he was first required to express an opinion as to the suitability of reinforced concrete as a shipbuilding material the structural designs were submitted to analysis which might have been a little crude, but were on safe lines and fitted usual shipbuilding methods. On coming to closer grips with designers the nature of the cleavage between the two points of view became more evident. There could be no question of the utility of such formulæ as those expressed in the L.C.C. regulations. Their value in directing the shipbuilder's attention to problems which required to be solved was undoubted, but it did not necessarily follow that they would provide quantitative results for hollow girders which must maintain watertightness under rapidly alternating stresses.

For these reasons it was necessary to ask if the formulæ could be applied safely to girders other than solid girders exposed to stress in one direction only, to solid girders where reliance was placed upon the steel reinforcement alone for tensile stresses, and upon the combined value of steel and concrete for compressive stresses or solid girders where the steel reinforcement did not as a rule exceed 1·5 per cent. of the total area of cross section. Shipbuilders were bound to ask the grounds on which the calculations referred to and which applied to land design could be expected to ensure the watertightness and strength of a hollow sea-going girder, the incomplete top member of which was exposed to tensile stress throughout its whole area. The shipbuilder was startled by the assertion that provision for hogging stresses could be safely based upon the assumption that the steel rods in the top deck represented the whole of the top member of the girder, and that these rods could be safely stressed in tension to over 7 tons per sq. in. That both steel and concrete should be taken into account in considering the compressive stress on the bottom and that the resulting position of the neutral axis was true in fact. It was quite obvious that under conditions of strain below the tensile strength of reinforced concrete the last assumption was untrue, and that the neutral axis must be in its familiar position at the centre of gravity of the area of the section. The questions to be settled were, if the neutral axis could be allowed to pass from that position in service, and whether the assumption as to its position might not be as dangerous as it was initially false.

Having regard to the relatively small area of concrete in which most designers of ships' scantlings embedded the tension members, it was apparent on the foregoing assumptions that the concrete all round the steel must fracture long before the stress on the rods approached 7 tons, thus endangering the watertightness of the structure. It was argued in reply to this that 15,000 lb. stress on the steel had been successfully withstood in circular water tanks, but against this was to be set the statement of Mr. de Burgh and other expert opinion that watertightness was not obtainable in such tanks if the stress on the steel exceeded 12,000 lb. per sq. in.

Summing up his views, the following appeared to be the practical and theoretical deductions which should guide reinforced concrete designs for ships. In the first, a ship girder was unlikely to perform its functions as a watertight sea-going girder unless its homogeneity was maintained under ordinary working conditions. As reinforced concrete lost this quality when the tensile stress exceeded the breaking stress of the concrete by 45 per cent., the structure should be designed to show a stress on the concrete within its own tensile strength of an order to leave a margin between ordinary and extraordinary stresses similar to that which experience has forced upon steel shipbuilders. As experience of reinforced concrete was derived from an average ratio of steel to concrete of 1 per cent., it did not seem reasonable to expect effective bend where the ratio exceeded 8 per cent., the figure at which the work was halved between steel and concrete. This must certainly be regarded as a very high figure for parts of the ship girder, where the whole material was exposed to tension, and should not be accepted without experimental evidence derived from hollow girders subjected to water under pressure when under tensile test. It was found that material of the quality usually proposed by designers was sufficient to justify the belief that it would comply with the condition laid down as to tensile stress in the concrete, although some redistribution was usually needed. Analysis of the stresses on a circular watertight tank showed that with 5 per cent. steel to 95 per cent. concrete the stress on the concrete came out at about 300 lb. per sq. in. if the steel area be proportioned to take up all the tension at 12,000 lb. per sq. inch. This seemed to support the argument that it was necessary to limit stresses on concrete and probably explained why the lower steel stress more often provided watertightness. It was felt that a maximum of 8 per cent. of steel would probably release the designer from fear that where steel was concentrated in mass the concrete would not lend its properties to the steel and *vice versa*.

His own opinion was that concrete could be used with success as a shipbuilding material within limits bounded largely by the tensile strength of the concrete, but that real advance in this type of construction would be severely restrained until the discovery of a waterproof covering having more than all the good qualities of concrete and which would not fracture until the stresses in the steel reinforcement were much higher than were at present possible.

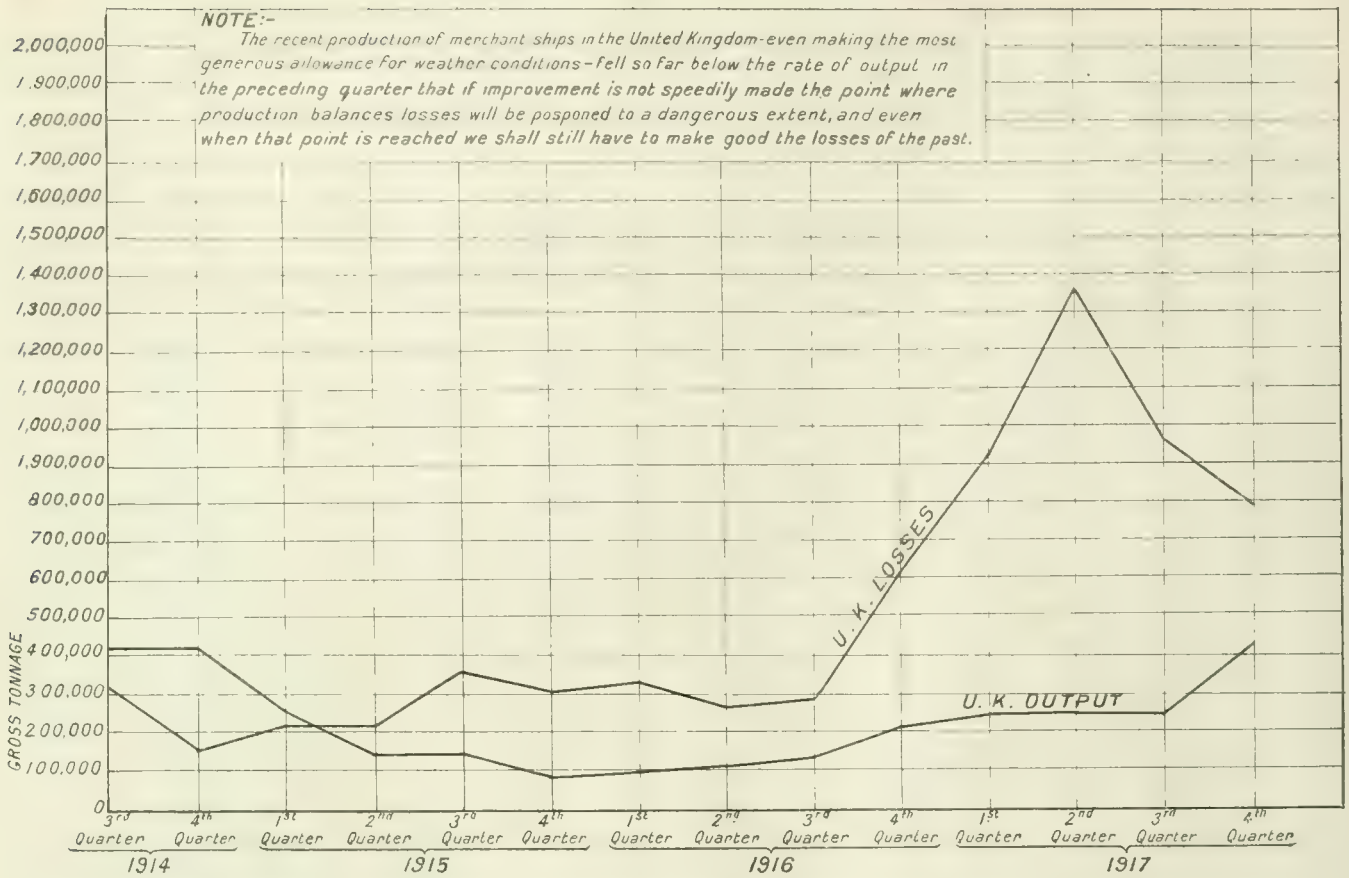
A Case for Concrete Ships.

Prof. T. B. Abell, who said he had been associated with Major Denny in his work on this subject, contended that a case had been made out for the ferro-concrete ship in present circumstances of supply of material and labour, and at a time when it was necessary to make all possible provision for relieving the demand on tonnage. In the concluding remarks of his paper, Major Denny discussed the limitation of the use of concrete for floating structures, and in the appendix showed clearly the very meagre prospect of a concrete vessel competing successfully commercially with a steel vessel, or even earning a dividend when freights returned to their normal level. In the present conditions, however, the policy of using reinforced concrete was justified. There was no doubt that nothing would revolutionise the shipping industry so much as the discovery of a new metal or alloy which was lighter and stronger and more suitable than steel, and which was at the same time so readily obtainable, and there could be no doubt that so far as sea-going craft were concerned we should be making a retrograde step in adopting a material such as concrete for ship construction. In spite of full inquiries, there were doubts in certain quarters, and there was one point in particular upon which he wished concrete engineers would enlighten shipbuilders. In the first place, he would quote the remark of a well-known American engineer on the use of concrete. He said, "All structural materials are prepared for use before reaching the job, and can be inspected as to quality before they are incorporated in the structure." In the case of a concrete ship, the manufacture of the material of construction was made on the spot, and actually at the time of incorporation in the hull, so that the success of the structure, however good the design, depended entirely upon the thoroughness and capacity and capability of the inspectors of the workmen, and also on the contractor. No land structure was subject to the various and varying stresses which a ship had to meet. For these reasons the naval architect, in accepting responsibility for this new material, must adopt factors of safety which would cover elements of which he had no practical knowledge, and upon which concrete engineers could not enlighten him. He was sorry he had not had an opportunity of studying Mr. Foster King's remarks before they were made, and which might almost form the subject of another communication. His chief point was that he was afraid of the watertightness being destroyed by reason of the tensile stress in the steel of the reinforcement being large enough to break the concrete, and, presumably, to break it up into sections between which there would be finite space through which the water could leak. That involved the fear that the bond between the reinforcement and the concrete was destroyed. Personally, he was inclined to doubt whether there was an actual slip between the concrete and the steel. He thought that the concrete must break up into a series of short sections of finite length with infinitely small interstices between the different sections. He, however, then came to a doubt himself working on those lines. One of the greatest defects of concrete was that it readily abraded; it wore out very rapidly under wear. Abrasion might take place in the internal structure of the ship, and Major Denny, in speaking of abrasion, might have the same thing in mind that he himself was now going to speak of. If the concrete broke up into small sections, distributed at intervals along the reinforcement under direct tension, when the ship was subjected to torsional movement there must be angular movement between these different sections. If there was such an angular movement, there must be abrasion at the surfaces of cleavage, and it was from that point of view that there might be trouble, and to cater for that they must adopt larger factors of safety. That could be tested by laboratory experiment. It so happened that in the structure of a ship bottom, the design could be so arranged that there was extremely little possibility of the tensile strength of the concrete being reached. In the deck, however, there was a good possibility, unless a sufficient margin of safety were taken, of reaching a tensile stress which would break the concrete, but he did not think the concrete would be broken up as to imperil the watertightness.

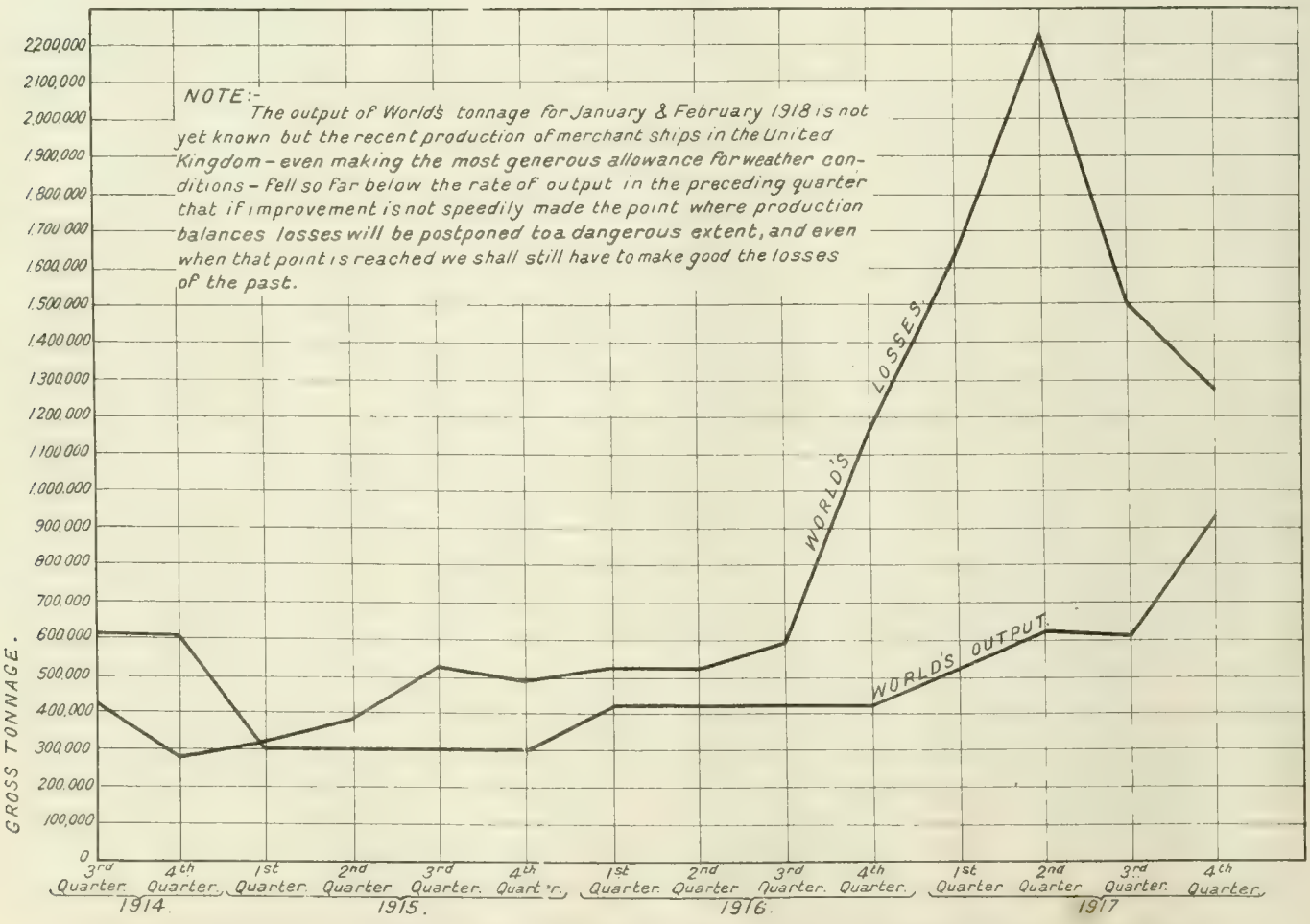
The Possibility of Improvements.

Captain Waller, R.E., said that in discussing the possibilities of the use of concrete for ship construction account should be taken of the fact that concrete might be expected to improve enormously in quality. Never before had concrete engineers had an opportunity of making such a valuable thing of concrete as a ship's hull. The appendix to Major Denny's paper showed that the cost of the hull was a very small item in the total value of the ship, but the quality of the hull was the point. He submitted that it was within the range of possibility that by being able to spend more money on making concrete the deadweight could be reduced very considerably. Present cements might not be the right sort to make concrete with for the quality required for ship construction. At the present time various experiments were being carried out on cements and a demand had been created for a super-cement. He had had a report on one cement consisting of one part cement and three parts Leighton Buzzard sand which produced a specimen giving 1,038 lb. to the square inch in tension. Therefore, he submitted that by spending more money on cement we should be able to improve it. Concrete of the quality now required had bever been wanted before and he believed that before long the quality would be very much improved. Having done that he contended that the concrete hull would be an infinitely better hull for many purposes than the steel hull, even in the higher type of ship. On the *Mauretania*, for instance, the vibration in the second class was appalling. The vibration in a concrete ship could not be like that. If it rose to the magnitude of a steel ship the concrete ship was finished. In factories, however, it was well known that the vibration in a concrete building full of machinery was nothing like so bad as that in a steel frame building, and he believed the bugbear of vibration would largely disappear from the concrete ship. The hull would be a bad conductor of heat and it would be possible to keep it cool in the tropics. They would not always have to be filling up with nauseating paint which produced that abominable smell which existed in nearly every passenger ship and made people seasick. It was only when the passengers went below into the smell of the paint that they became seasick, and he believed it was within the range of possibility that the concrete hull would be better than the steel hull even for very large construction. It might be said that the concrete ship would go a bit slower, but he did not worry about that, because the man who wanted to go quickly over the Atlantic, and possibly uncomfortably, would fly over, whilst the man who wanted to go comfortably over would choose a concrete ship.

The remainder of the discussion on these papers and Mr. Robb's and Mr. Allen's papers will be dealt with in our next issue.



Graph showing Losses by Enemy Action and Marine Risks: and Shipbuilding Output of the United Kingdom.



Graph showing Losses by Enemy Action and Marine Risks: and Shipbuilding Output of the World.

MERCHANT TONNAGE AND THE SUBMARINE.

The War Cabinet have received a request from the Board of Admiralty that the full facts of the tonnage position should now be published. The War Cabinet, with the concurrence of the Allies, have agreed to this request, and have sanctioned the issue of the following memorandum prepared by the Board of Admiralty :—

Hitherto the Board of Admiralty have been averse from any publication other than that contained in the weekly return of losses, although it has frequently been pressed upon them that the whole tonnage facts should be made public. So long as such publication would encourage the enemy and would stimulate his energies in a dangerous direction, they have not been able to concur in the proposal. The figures to-day will not stimulate the enemy, and the Admiralty recognise that the policy of silence, necessary as they believe it to have been from a naval point of view, has had this serious defect—that it failed sufficiently to impress upon the people of this country the vital necessity for individual and united effort on their part to make good the losses caused by enemy submarines.

In the spring of 1917 the full menace of the submarine campaign was first disclosed. Since that date we have steadily increased our knowledge and our material resources for this novel warfare.

Three statements are attached showing for the United Kingdom and for the world, for the period August, 1914, to December, 1917 :—

1. Losses by enemy action and marine risk ;
2. Mercantile shipbuilding output ;
3. Enemy vessels captured and brought into service.

Diagrams showing in graphic form the losses and shipbuilding output for the United Kingdom and for the world are also attached.

The situation should be viewed from the standpoint of the world's tonnage, as in these problems the mercantile navies of the whole world, excluding the enemy, may be regarded as one.

It will be noticed that the diagrams record facts and that nothing has been included in the nature of an estimate. The point where the lines will intersect depends on the skill and energy of the Allied navies on the one hand, and the determination of employers and men in the shipyards and marine engineering shops on the other.

On the subject of losses, the Admiralty disclaim any desire to prophecy about so uncertain a thing as war in its submarine phase. The results of the past year have shown the ability of our seamen to get upon terms with the submarine menace and gradually to gain the upper hand. This result has been achieved in spite of an imperfect knowledge of a new and barbarous method of warfare and of a scarcity of suitable material. Our material resources for this warfare are already improved and are being rapidly augmented, whilst science is placing at our disposal means of offence and defence of which we have been in need.

With regard to the other factor, a rapid and continuous increase in the output of merchant tonnage will inevitably follow the united efforts of all engaged in merchant shipbuilding in this country.

The recent production, however, of merchant ships in the United Kingdom, even making the most generous allowance for weather conditions, fell so far below the rate of output in the preceding quarter that, if improvement is not speedily made, the point where production balances losses will be postponed to a dangerous extent, and even when that point is reached we shall still have to make good the losses of the past.

During the critical period that confronts us we must rely to a large extent on our own shipyards and on ourselves. Our partners in the war are making every effort to increase their production of ships, but a considerable time must elapse before the desired output is secured.

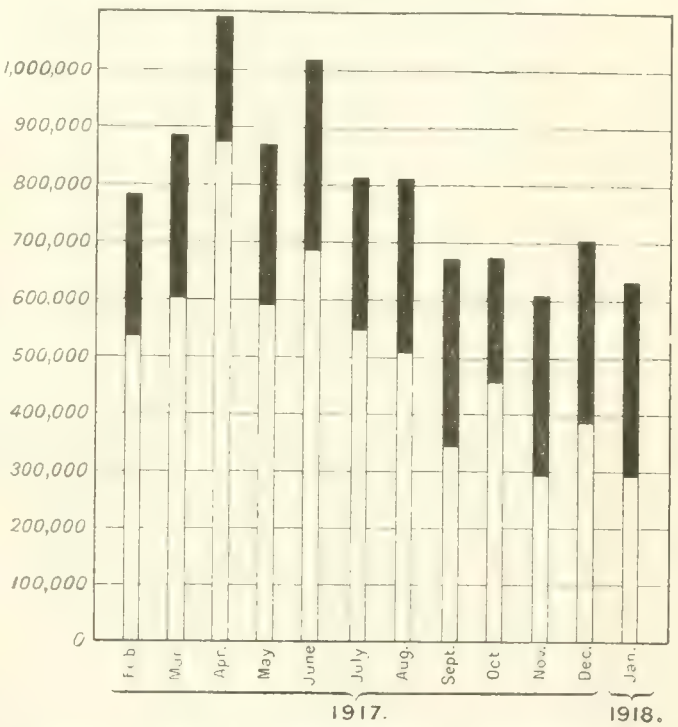
To produce in the United Kingdom 1,800,000 tons in 1918, and to reach an ultimate production at the rate of 3,000,000 tons per annum, is well within the present and prospective capacity of our shipyards and marine engineering shops. But the ranks of the skilled men must be enlarged without delay by the introduction of men and women at present unskilled. The education of these newcomers, up-grading, and interchangeability of work are essential, and must be pressed on with the goodwill of employers, foremen, and men.

Further, the Board of Admiralty wish to make it perfectly clear that these results cannot be obtained unless maximum output is continuously given in every shipyard and marine engine shop by every one concerned.

It is to ensure the vigorous co-operation of all concerned that the Admiralty have recommended the publication of the facts.

The following table summarises the position at the end of 1917 :—

	British.	Foreign.	World.
Losses	7,079,492	4,748,080	11,827,572
Gains :			
New construction .. .	3,031,555	3,574,720	6,606,275
Enemy tonnage captured .	780,000	1,809,000	2,589,000
Total gains . ..	3,811,555	5,383,720	9,195,275
Net loss (World)			2,632,297



World's Losses by Enemy Action. Comparison of German and British Figures (Black extension shows German exaggeration).

Statement showing United Kingdom and world's merchant tonnage lost through enemy action and marine risks since the outbreak of war :—

Period.	United Kingdom. Gross Tons.	Foreign. Gross Tons.	Total for World. Gross Tons.
1914			
August and September .	314,000	85,947	399,947*
4th Quarter	154,728	126,688	281,416
1915—			
1st Quarter .. .	215,905	104,542	320,447
2nd Quarter ..	223,676	156,743	380,419
3rd Quarter	356,659	172,822	529,481
4th Quarter . ..	307,139	187,234	494,373
1916—			
1st Quarter	325,237	198,958	524,195
2nd Quarter	270,690	251,599	522,289
3rd Quarter	284,358	307,681	592,039
4th Quarter .	617,563	541,780	1,159,343
1917			
1st Quarter .. .	911,840	707,533	1,619,373
2nd Quarter . ..	1,361,870	875,064	2,236,934
3rd Quarter	952,938	541,535	1,494,473
4th Quarter	782,889	489,954	1,272,843
Totals	7,079,492	4,748,080	11,827,572

* This figure includes 182,829 gross tonnage interned in enemy ports.

Statement showing output of merchant shipbuilding of the United Kingdom and the world (excluding enemy countries) since the outbreak of war:—

Period.	United Kingdom. Gross Tons.	Foreign. Gross Tons.	Total for World. Gross Tons.
1914—			
August and September	253,290	337,310	1,012,920
4th Quarter	422,320		
1915—			
1st Quarter	266,267		
2nd Quarter	146,870	551,081	1,202,000
3rd Quarter	145,070		
4th Quarter	92,712		
1916—			
1st Quarter	95,566		
2nd Quarter	107,693	1,146,448	1,688,000
3rd Quarter	124,961		
4th Quarter	213,332		
1917—			
1st Quarter	246,239	282,200	528,439
2nd Quarter	249,331	377,109	626,440
3rd Quarter	248,283	368,170	616,443
4th Quarter	419,621	512,402	932,023
Totals	3,031,555	3,574,720	6,606,275

Statement showing enemy tonnage captured and brought into service by the United Kingdom and by Allies since the outbreak of war:—

Period.	United Kingdom. Gross Tons.	Allies. Gross Tons.	Total. Gross Tons.
1914—			
August and September	725,500	453,000	1,178,500
4th Quarter	28,000	5,000	33,000
1915—			
1st Quarter	5,000	1,000	6,000
2nd Quarter	500	500	1,000
3rd Quarter	3,500	6,000	9,500
4th Quarter	2,500	—	2,500
1916—			
1st Quarter	—	241,000	241,000
2nd Quarter	3,500	8,000	11,500
3rd Quarter	—	47,500	47,500
4th Quarter	—	—	—
1917—			
1st Quarter	—	-	-
2nd Quarter	7,000	702,500	709,500
3rd Quarter	4,500	266,500	271,000
4th Quarter	—	78,000	78,000
Totals	780,000	1,809,000	2,589,000

SHIPBUILDING AND ADMIRALTY CONTROL.

The First Lord's Speech.

As the speech which Sir Eric Geddes made in the House of Commons on Wednesday of last week has been so fully reported in the Press generally, and, moreover, as the bulk of his arguments centred around the statistics since published as a White Paper and given in full in this issue, we do not propose to enter into the details of the First Lord's remarks.

Sir Eric Geddes said that the world's tonnage, from the commencement of the war until December 31, 1917, exclusive of enemy-owned tonnage, had fallen by a net figure of, roughly, 2,500,000 tons. This was out of 33,000,000 estimated Allied and neutral ocean-going tonnage, which was arrived at after deducting small craft, river and estuary craft, and a considerable amount of lake tonnage, tugs, &c. So that with a net loss of 2,500,000 tons, on an estimated ocean-going tonnage of 33,000,000 tons, we had suffered, the Allies and neutrals, about 8 per cent. reduction in ocean-going tonnage of the world, excluding enemy countries. The total world's tonnage, exclusive of enemy tonnage, was 42,000,000 and the deduction was made after the most careful consideration and investigation. We were over 1,300,000 tons to the bad from all causes before the intense submarine campaign started. Losses from ordinary marine risks were included in the figures. The percentage of net loss of British tonnage alone was 20 per cent. The enemy claimed to have sunk 9,500,000 tons of British, Allied and neutral shipping. The actual figure was roughly 6,000,000. As regards our shipbuilding output we produced in the fourth quarter of 1914 420,000 tons, in the corresponding periods of 1915 92,000 tons, of 1916 213,000 tons, and 1917 420,000 tons. By an increase in the output last quarter and a decrease in sinkings, on the average per month, the Allies were within 100,000 tons a month of making good the world's losses due to enemy action and marine risk. British losses were relatively higher, but we had contributed the greatest naval effort. Considerable strides had been made in the organisation of repair work and in February we completed repairs at an average of 166 ships, or 500,000 tons, per week. They had reached in 1917 a total warship and merchant tonnage output practically equal to the biggest shipbuilding year this country had ever known. They had multiplied by 10 times the number of naval craft repaired and refitted, and in six months had increased the merchant ship repair tonnage by 80 per cent., or an increase of 237,000 tons per week.

In defending the Admiralty Controller's Department, the First Lord referred to the "fabricated ship." It is, he said, known as "N" design, and is technically called the "Fabricated" ship; it is manufactured in parts by repetition throughout the country and assembled at the yard. One of our most successful shipbuilders, after examining it in detail, came to the conclusion that it was so satisfactory, and could be built so much quicker, that it was in the national interests to cancel certain repeat orders for other standard ships which he was about to lay down, in order to substitute this new "N" type of ship for them. Comparing this type with the type "A," we get 2,470 tons additional deadweight capacity for an extra 11½ ft. in length. Each ton of net steel in the new type will yield 4·06 d.w. tons against 3·53 d.w. tons for each ton of net steel in the original type—an increase in carrying capacity of 15 per cent. for each ton of steel. The "N" type of "fabricated" ship is the one which is going to be built in the national shipyards, as well as elsewhere.

As regards the labour question, it was hoped to obtain the release of skilled men more speedily then hitherto, but even when all were obtained much remained to be done by upgrading and dilution. The steel difficulty had been overcome. The men were beginning to flow into the yards in increasing numbers, and the yards were getting cleared out and allotted to work most suited to them. Not only in shipbuilding, but in ship repairing and in preparing the way for a much greater output, the Controller's Department had done work of inestimable value. He believed that the shipbuilding problem was in a fair way to be solved. He believed also that the organisation of the Controller was to-day solving it.

In order to obtain the most experienced and the most highly qualified advice and assistance the Government had asked Lord Pirrie to take, and he had accepted, the position of Controller-General of Merchant Shipbuilding, directly under the First Lord, and not on the Board of Admiralty. He would concern himself solely with merchant shipbuilding—not naval—and would be above the Controller in this matter.

Proceeding, Sir Eric said that Lord Pirrie's Belfast Yard was not a tramp-building yard before, and it required a good deal of adjustment of machinery, labour, and yard conditions before it could be used for the purpose of building standard ships, and the results there are far better than in any other yard in the Kingdom. Lord Pirrie, therefore, had an undoubted right to express opinions on this question of standard ships, of design, and the Departmental organisation charged with the production of ships on behalf of the Government, and his advice had been of great value in regard to the national shipyards. Lord Pirrie had built standard ships and oilers in far shorter time than anyone else had turned out identical craft. This applied not only at Belfast, but as regarded oilers on the Clyde too. He had beaten all records all over the country. More than half the standard ships completed have come from his yards, and Lord Pirrie hoped to launch one every fortnight before long. As a matter of fact, he was already completing these ships in five and a half months from the date the keel is laid, and he hoped to complete ships in under 4½ months in future on the design explained by Sir Eric. These, he said, were absolutely unrivalled results. Lord Pirrie was enthusiastic about the value to the country of the national shipyards, and on the outlook for rapid production in them of the new "N" type of "fabricated" ship. Moreover, Lord Pirrie had told him that he would have been unable to give the results he had given, or to expect the great reduction of time in building standard ships had it not been for the great help, co-operation and common-sense treatment he had received from the Controller's Department. While the Controller-General would be directly responsible to the First Lord, he would have direct access to the Prime Minister and the War Cabinet. It should be stated that owing to Harland and Wolff being a private limited company, it was not possible for Lord Pirrie formally to retire, but he would take no active part in the direction of Harland and Wolff, or its subsidiary companies, so long as he was devoting his time to the mercantile shipbuilding programme.

GENERAL NEWS SECTION.

PERSONAL.

The Right Hon. Lord Pirrie, whose appointment as Controller-General of Merchant Shipbuilding at the Admiralty was announced by the First Lord last week, and which appointment is referred to more fully on page 368, is one of the best-known figures in the shipbuilding world. Born in Quebec in 1847, he was, within a few years, settled in Belfast, and when 15 years old, was taken from school and entered as a premium apprentice with Harland & Wolff, then a four-year-old concern. With that energy and resource which has accompanied him through life, he set himself to the daily tasks, and at 22 years of age was head draughtsman. Sir Edward Harland, realising the potentialities of his man, admitted him as a partner about five years later. Of the growth of the firm under Lord Pirrie's impulse, and the many other associations, not only in shipbuilding, but also in shipowning on a large scale, there is little need to speak. Suffice it to say that the appointment as Controller-General, being, in fact, the pinnacle of merchant shipbuilding control, is a fitting climax to a career which has been so largely identified throughout life with the shipping and two paramount industries of this country.

[Photo. [Lafayette.

The Right Hon. Lord Pirrie, K.P.,
Controller-General of Merchant Shipbuilding.

The following messages have passed between the employees of Harland & Wolff's works at Belfast and Glasgow and Lord Pirrie on the latter's appointment as Controller-General of Merchant Shipbuilding:—

"Belfast,
March 21, 1918.

"The staff, foremen, leading hands and men in Harland & Wolff, Ltd., Belfast, desire to congratulate your Lordship on the distinction conferred on you by your appointment as Controller-General of Merchant Shipbuilding at this critical stage in our National history, and pledge you our continued loyal support and earnest endeavour to strengthen your hands in the great task you have undertaken."

Lord Pirrie replied: "I appreciate deeply the congratulations of the staff, foremen, leading hands, and men of the Queen's Island, whose splendid work for the Nation has now been publicly acknowledged, and the assurance that I can rely still further on their willingness and enthusiasm makes me feel more than ever confident that the output of ships will be increased to the desired extent, and the menace to the country overcome.—Pirrie."

"Glasgow, March 23.

"All sections of the staff and the shop stewards on behalf of all trades in Harland & Wolff's Govan Works unite in offering your Lordship their hearty congratulations and best wishes on your appointment to the position of Controller-General of Merchant Shipbuilding, which they realise is one of the highest importance in the present difficult situation, and they have every confidence in your Lordship's ability to achieve the greatest possible results, and will themselves support you to the fullest extent in their power by making fresh records for speedy construction of merchant ships."

In reply, Lord Pirrie said: "I am much touched by the kind message of congratulation from the staff and shop stewards on behalf of all trades in the Govan Works. The knowledge of their determination to improve past records of output is an encouragement to myself and confirms me in my belief that the noble efforts of our men in France at this time will be fully seconded by all at home. I am sure that all will realise that every hour's work on ships is of vital importance, not only to our men in the fighting line, but for the maintenance of the supplies at home.—Pirrie."

Second Lieut. Douglas Smith, who has been mentioned in despatches, is the younger son of Captain W. R. Smith, Cardiff, and is junior partner in the firm of W. R. Smith & Sons, shipowners, Cardiff Docks. He joined the R.G.A. on August 15, 1914, and afterwards secured a commission, and has been with the Mesopotamia Expeditionary Force for two years.

Mr. H. R. Jones, general manager of Guest, Keen & Nettlefolds' collieries, and Mr. A. S. Tallis, general manager of the Tredegar Iron & Coal Co., have been elected chairman and vice-chairman respectively of the Monmouthshire & South Wales Coalowners' Association for the ensuing year.

FROM OUR CORRESPONDENTS.

CLYDE DISTRICT.

(From Our Own Correspondent.)

The Clyde and the I.N.A.—The newly elected Council of the Institution of Naval Architects again includes a good representation of Clyde shipbuilders. Among the members of the Institution who have been re-elected to the Council are Mr. James Hamilton, of the Fairfield Shipbuilding & Engineering Company; Mr. W. J. Luke, of John Brown & Co., Clydebank; and Mr. Harold E. Yarrow, of Yarrow & Co., Scotstoun. The re-elected associate members of the Council include Lord Inverclyde.

Housing of Shipyard Workers.—Good progress is being made by the District Director of Auxiliary Shipbuilding on the Clyde for the housing of the many thousands of additional workers who are being brought into the district for the speeding up of shipbuilding work. In addition the hotels and other buildings, which have already been taken over and converted into hostels for the accommodation of workmen, a large new building has been acquired in the Scotstoun district. In this building, which was originally intended for educational purposes, it is hoped to accommodate 3,000 men. Proposals have also been made for the temporary taking over of several schools on both sides of the river. Special arrangements have been made for supplying provisions to those who are coming to the district.

NORTH-EAST COAST DISTRICT.

(From Our Own Correspondent.)

Government Control.—That Government control has never been conducive to getting the best out of any industry is now a deep-rooted conviction with Lord Joicey. On several occasions he has publicly ventilated his views on this question, and at the annual meeting, over which he presided, of the North of England Steamship Owners' Association in Newcastle, he again referred to the subject, and, in alluding to the falling-off in shipbuilding, he attributed this not to want of material, but to Government control. No one could persuade his lordship, he said, after a life-long experience in business, that great industries could be carried on as successfully and with the same output by Government departments as they could by private enterprise.

Lord Joicey feels that if the Government, instead of taking control of the shipbuilding industry and going in for standard ships, had left the shipbuilders to build their own standard ships, the results would have been more satisfactory.

Mr. H. M. Cleminson, the General Manager of the Chamber of Shipping, has been spending a few days on Tyneside, and he attended the annual meeting of the North of England Steamship Owners' Association in Newcastle. He was accorded a very hearty welcome, and in a word or two of acknowledgment he said the Chamber of Shipping had taken on new life, and might be expected to prove of greater value in the future than it had been in the past. The desire was to perfect the organisation, and to get more of the opinions of the individual shipowner with a view to the pursuance of a common policy. The intention of those responsible for the reconstruction of the Chamber was to give a fresh stimulus to the shipowners' meetings in the various ports of the kingdom, and he mentioned that Government control was one of the most important things on the tapis at present. He hoped the Government would declare in favour of the liberation of shipping at the earliest opportunity.

THE MERSEY DISTRICT.

(From Our Own Correspondent.)

Warehouse Rates.—It was reported to the Mersey Docks and Harbour Board on Thursday that the revisers had passed the new schedule of warehouse rates, approved by the Board at its previous meeting. The new rates are to come into force on April 1, and the new Warehouse Book, when printed, will contain numerous photographic reproductions showing the accommodation and facilities which the port can offer.

Earnings of Shipping Companies.—The report of the Lamport & Holt Line, just issued, confirms the belief held in shipping circles here that the earnings of the large shipping concerns for 1917 will not equal those of 1916. Indeed, the net earnings of this particular company are down by roughly £150,000, and although the 10 per cent. dividend paid last year is again recommended, this is only made possible by carrying to reserve only £50,000, against £150,000 last year, and to insurance fund, £50,000, compared with £100,000 last year. The report states that during the year four new steamers were delivered, representing 24,026 tons, while on the other hand five steamers, aggregating 27,543 gross tons, were lost.

"**Electric Welding.**"—This was the subject of a paper read before the Liverpool Engineering Society on Wednesday last by Mr. T. S. McKay, A.M.I.N.A., manager of the British Arc Welding Company. After describing the progress made during the last 25 years or so in the two main methods of applying electricity for welding purposes, Mr. McKay proceeded to detail some interesting examples of welding repairs which, especially during the last few years, had been successfully carried through under his direction. In a reference to the welding repairs carried out by the Americans to the German ships seized in United States harbours, Mr. McKay said these in no way overshadowed what was capable of being done in this country; indeed, he said, British welding methods could claim to be as advanced and up-to-date as those of our cousins across the water, the large number of repairs so successfully dealt with in this country must, he said, convince the most sceptical that there is a wide field and great possibilities for electric welding even with the metals not mentioned in his paper.

SOUTH WALES DISTRICT.

(From Our Own Correspondent.)

Shipbrokers and their Fees.—At a recent meeting of the Cardiff Shipbrokers' Institute it was explained that in the case of Newcastle boats being directed to load from the Bristol Channel, a broker was employed in the national course of things, but that broker was not entitled to any commission at all; the only remuneration was the clearance of fees and commission on bunkers. The matter was discussed with the Director of Shipping (Sir Ernest Glover). The Local Committee for the Supply of Coal to France and Italy promised their support to the brokers, and steps were taken to approach the Ships' Licensing Committee to direct steamers to the Bristol Channel, but not to direct them to any particular firm. The following letter has now been received from Sir Ernest Glover:—"The question has been carefully considered in view of what you and others have told me in reference to the work both in respect of arranging on charter and in respect of duties connected with clearance, &c. The upshot of it is that it has now been arranged that no brokerage should be paid at all where a manager of an ex-neutral vessel is instructed to fix with a named character, or to apply to the Local Committee and fix according to their directions. Instead of brokerage it has been decided in all cases to pay a higher agency fee, and this has been settled at 15 guineas where a steamer loads at a port other than that at which the manager is resident. I hope you will agree with me that this is a reasonable way of meeting the difficulty." This intimation has been received with general satisfaction, it being pointed out that the loss of the brokerage is more than compensated for by the enhanced commission fee of £15 15s.

THE FREIGHT MARKETS.

(From Our Own Correspondents.)

London.—On the Baltic Exchange the demand remains good for available tonnage, and rates keep very firm in all directions. From the River Plate to the United Kingdom the current rate is 200s. and to France 205s. The ports of the North American Atlantic seaboard are interested in tonnage on net form of charter, and 230s. is offered to the United Kingdom, 270s. to France, 350s. to French Mediterranean ports and 360s. to Italy. For heavy grain the ruling figure is 50s. to this country, 57s. 6d. to France and 75s. to 77s. 6d. to the Mediterranean. Business could be done with coal cargoes from Virginia to the Plate at 80s., and for sugar from Cuba to France 305s. is offered. Nitrate business is worth about 185s. to the United Kingdom. In the East the demand is strongly maintained. Karachi can be done at 250s. on scale basis to the United Kingdom, and Bombay 275s. to the same destination, or 400s. to the Mediterranean. Kernel cargoes offer at 550s. from the

Madras Coast to Marseilles, but at this figure tonnage is not forthcoming. The rice ports are also competing for carrying space, and 500s. to 550s. can be had from Burmah or Saigon to this country or France. For salt cargoes, Torrevieja is willing to pay 90s. to Chittagong. In the Mediterranean section of the market chartering is being done on the basis of 45s. Huelva to the Mersey, 60s. Huelva to the East Coast United Kingdom with pyrites, 50s. Bougie to the Clyde and 65s. Tunis to the same destination, 70s. Sfax to the Bristol Channel, and 50s. Bilbao to Boulogne. Bay fixtures have been made at 17s. Bordeaux to Bristol Channel and 20s. Bayonne to the same destination.

Glasgow.—The local market has been without feature since our last report. Business has been inactive owing to the lack of boats and rates have been firmly held in all directions. The following were among the fixtures reported: steamer, Glasgow to Barcelona, 2,800 tons, 420s.; steamer, Bordeaux to Bristol Channel, 17s.; Virginia, 5,000 tons; Buenos Ayres, 80s., coal, prompt; and steamer fixed on time charter, general trade, 46s. 6d., six months.

Newcastle-upon-Tyne.—Northumberland steam coal collieries continue to be very fully employed in the output of coal, mainly on official account, and are well supplied with requisitioned steamers. Prospects right up to the holidays are quite good. Durham gas-coal pits, also, are sharing in the fillip which has been given to trade by these official requirements and are now working even more fully than was the case when the previous report was written. Apart, however, from the considerable influx of official vessels, the shipping traffic in the river is not very extensive at present. Neutral steamers are conspicuous by their absence, with the result that exceedingly little chartering is possible. Since last report, a couple of "free" vessels have been fixed for the carriage of coke to the North French Range at the scheduled rate of 46s.; a 4,800-ton steamer has been taken up for Huelva at 420s.; a 4,500-ton vessel has been fixed for Monte Video at 120s., and a 2,350-ton steamer has been taken up for Stockholm at 175 kr. These are all the fixtures that have been reported. The Stockholm rate indicates some increased firmness in the price of cargo space for Swedish ports, as compared with a fortnight ago. The Huelva fixture—at a rate which is a record for that particular port, and, indeed, far and away the highest figure ever paid for any European port on this side of the Strait of Gibraltar—denotes that the Spanish ports have lost none of their recent firmness and that anyone "getting on" from Barcelona in the near future at 440s. may account himself exceedingly lucky, fabulously high as that figure would have appeared only a few months ago. Rates for the coaling stations are nominally unaltered at 100s. to Gibraltar and 200s. to Port Said. Portuguese ports press for tonnage at 115s. to Lisbon and 125s. to Oporto. Rates in all other directions are fully maintained. There is still an entire absence of coasting business. Allied tonnage for shipment for the French Atlantic is more plentifully offered and the Exports Committee is allocating vessels more freely at firm scheduled maximum rates, but the demand is still far in excess of the supply.

Liverpool.—Outward freights maintain a firm tone consequent upon orders current which are far away in excess of tonnage available. What business is passing is on Allied account, and shipping being below requirements, neutral ports get no chance. A noteworthy fixture is that Cardiff paid 13s. for South Wales coal to Birkenhead. Time chartering rates are firm, and 35s. continues to be paid for round trips in the States-West Indies trade, while 49s. to 50s. is still indicated for suitable neutrals in the European general trades. In the homeward trades Eastern markets show much eagerness to get tonnage, and while 470s. is reported paid for part cargo rice, Saigon to Marseilles, Rangoon offers 425s. to Cuba, Calcutta 80 dollars, jute, to San Francisco and Malabar Coast, copra 100 dollars to San Francisco. Burmah indicates 500s., but tonnage response is not good. Net form of charter can be done to London or Liverpool. North America maintained a steady inquiry at 260s. to French Atlantic, 330s. to Marseilles, and 360s. to Genoa from the Range ports. River Plate has a firmer tendency and quotes 200s. to 205s. to United Kingdom or North France.

Cardiff and Swansea.—There has been no diminution in the inquiry. Rates for all directions continue firm, but the tonnage position remains practically unaltered. The business disclosed comprised two steamers for Birkenhead at 13s. and 14s., discharge free. The French ports were represented by Granville, 46s. 6d.; Caen, 48s.; Rouen, 73s. 3d. coke; Nantes, 61s. 6d.; Bordeaux, 69s.; all neutral vessels. Two small sailing vessels were done at 130s. for La Rochelle. Gibraltar was again fixed at 100s., and a fixture done recently for Huelva at 420s. was disclosed. On the Swansea market the demand for tonnage was still active, and no difficulty was experienced in obtaining recent rates. No business was disclosed except for the French ports at the maximum limitation figures.

Hull.—The general conditions of business are difficult owing to the shortage of tonnage which these last few days has been marked in all sections. In the North French market there has been a strong inquiry with fairly active results in allocated tonnage. In the West Italian trade greater difficulty has been felt in obtaining tonnage and only a quiet trade has been possible. Chartering to neutral destinations has been on the quiet side.

COMPANY REPORTS AND DIVIDENDS.

Irrawaddy Flotilla Company, Ltd.—The directors recommend a dividend of £3 per share, free of income tax, making £5 per share for the year, against £6 for the preceding year.

Baldwins, Ltd.—The directors have declared an interim dividend payable on April 6, 1918, of 2½ per cent., free of income-tax, on the amount paid up on the ordinary shares for the half-year ended December 31, 1917.

Newhaven Harbour Company.—The report for the half-year ended December 31, 1917, mentions that State control of the harbour still continues. An instalment of £40 has been paid during the half-year towards the liquidation of the debt to the Public Works Loan Board, which now stands at £40.

Graham's Navigation (Merthyr) Collieries, Ltd.—The report for the year ended December 31, 1917, states that on capital account the sum of £1,387 was expended during the year on pithead cover and new offices at the colliery. The quantity of coal raised was 122,369 tons, against 125,993 tons in 1916 and 113,263 tons in 1915. The collieries worked regularly throughout the year, and a large percentage of the coal produced was again shipped for Admiralty account. The profit and loss account, after providing for excess profits duty to end of 1916, payments of debenture interest, final dividends for 1916, and interim dividends for 1917, show, after transferring £2,000 to reserve for depreciation, a credit balance of £20,755, which the directors propose to deal with as follows:—To pay a final dividend of 20 per cent. per annum (making 15 per cent. for the whole year), £3,000; final dividend on the 6 per cent. preference shares, £360, both less income-tax, and to carry forward the balance of £17,395. The profits for the year 1917 are subject to excess profits duty and coal mines excess payments not yet fixed, as the matter of a substituted standard under the Coal Mines Agreement (Confirmation) Act, 1918, remains to be settled with the Controller of Mines.

COMPANY REGISTRATIONS.

Charles Booth & Co., Ltd.—Capital, £22,000, in 20,000 preference shares of £1 each and 40,000 ordinary shares of 1s. each. Objects: Dealers in new and second-hand plant, machinery and tools, metal merchants, marine and ships' store dealers, shipowners, shipbuilders, ships' riggers, ship furnishers, ships' chandlers' etc. Signatories:—

H. W. Carlin, 4, Knaresbrough Place, Earl's Court, S.W., bookkeeper.
H. Pont, 7, Garden Grove, S.E. 5, company registrar.
L. Neuk, 1, Lawn Mansions, Gondar Gardens, N.W., bank accountant.
T. Jarvis, 59, Wavendon Avenue, Chiswick, W., accountant.

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QUESTIONS IN PARLIAMENT.

Tonnage Output.

Mr. Joynson-Hicks, on March 20, asked the Secretary to the Admiralty whether ships were launched in November and December of last year before they were in a proper condition to be put into the water.

Dr. Macnamara: The figures of output do not deal with launchings at all. They give the tonnage of vessels completed and handed over for service. No question, therefore, of launching vessels during the latter months of the year, before they were in proper condition, can arise.

Output on the Clyde.

Answering Col. Sir F. Hall, on March 20, Dr. Macnamara said: Undoubtedly, the actual output on the Clyde for December, 1917, fell seriously below the official forecast; that for January, 1917, more seriously below the official forecast. I am afraid I am not in a position to give precise percentages.

Sir F. Hall: Why cannot the right hon. gentleman tell the House the actual percentages? Have they not been worked out?

Dr. Macnamara: I told my hon. friend on a former occasion that a very serious defect indeed had occurred in the output because of the strikes, but it would be very difficult to say precisely in percentages the effect.

Sir Fortescue Flannery: Can the right hon. gentleman say what is meant by output? Does he mean the tonnage launched, tonnage completed, or the number of tons of material worked into ships in course of construction?

Dr. Macnamara: I should say the second—tonnage completed.

Sir F. Hall: Does the right hon. gentleman not think, in view of the serious state of the shipbuilding industry, that it would be to the general interests of the country if he were able to give the figures showing exactly what losses we had sustained in consequence of these strikes?

Dr. Macnamara: I have categorically answered the question as closely as I could. If we were to give arithmetical calculations on definite points, and if inadvertently they were untrustworthy, then we should have controversy on that particular reply.

NEWS PARAGRAPHS.

Norwegian Marine Insurance.—According to a Reuter message from Christiania, the Norwegian War Insurance Department for goods has lowered the premium for trade with England from 4 to 3½ per cent.

Paisley Shipbuilder's Gift.—Intimation has been received by the governors of Paisley Technical College that Mr. William Bow, a well-known shipbuilder of the town, has decided to present his former residence, Dunscore House, Paisley, to the college authorities as a permanent residence for the Principal of the College. The gift is free of all feu-duties. The governors, in appreciation of Mr. Bow's generosity, have elected him a life-governor of the college. Mr. Bow is one of the principal partners of the firm of Bow, McLachlan & Co., shipbuilders and engineers, Paisley.

Seamen's Insurance.—The Tyne Committee of the Seamen's National Insurance Society report that in the past year there were eleven meetings of the Committee at the Shipping Office, South Shields. So far as final accounts were concerned they were only available to the end of 1914. The latest statistics the Committee had were to the end of December, 1916, showing that the income had been £291,623, and the disbursements £219,147, leaving an apparent credit balance of £72,476.

North of England Steamship Owners' Association.—The annual report was of much smaller dimensions than usual, for reasons of economy in paper and printing. One of the chief items touched upon was the Finance Bill of 1917, which, it was stated, treated invidiously with the profits of shipping. Shipping, in addition to paying 80 per cent. excess profits duty, was deprived of the privilege, enjoyed by every other trade, of averaging losses or reducing profits against previous excess profits for taxation. Representations were made to the Chancellor of the Exchequer, and while the efforts of the shipowners were not successful in obtaining the withdrawal of the clause which cancelled the shipowner's right to average losses, some little concession was gained.

SHIPPING SHARE MARKET.

The stock and share markets have been inactive and dull, owing to the absence of money requiring investment, the War Bond campaign having been followed by several new issues of capital approved by the Treasury. The shipping section has suffered in common with other markets, and prices are slightly lower as a result. Cunards, whose accounts are awaited with considerable interest, have been the principal feature with business marked at over 85s. A number of dealings have taken place in Peninsular and Oriental deferred at around 336, and the preferred stock has also found buyers. Among the minor shares there has been some fluctuation in Court Lines, with a recovery at one time to over 36s. 9d., and Argentine Navigation issues have again attracted a little attention. Prince Lines have been dealt in at 5¾–6 ex dividend, which is an improvement on the previous week's quotation. Irrawaddy Flotilla are paying £3 per share, making £5 per share as against £6 a year ago. The iron and steel section and shipbuilding companies' issues generally continue to arouse interest, especially among provincial investors, but the volume of shares available is very limited, with the result that dealers are compelled to put prices higher than is in all cases justified. The leading shipbuilding companies' issues now yield about 6 per cent. and over, but the certainty that the yards will be full up with orders for some years to come, as the result of the U-boat warfare on mercantile vessels, is leading investors to take long views and to lock up their holdings with the prospect of getting a substantial profit in three or four years' time when the excess profits duty may not bear so heavily on the profit and loss accounts of the companies. Cammell Laird shares at over 6¾, Guest Keens at 85s., Armstrongs at 43s., Vickers at 43s. 9d., are all in demand. Richardsons Westgarth are not so active now that the scheme of reconstitution is practically settled and the price of the ordinary is marked 9s., and the preference 17s. 6d. Workington Iron shares are still being purchased, owing to the directors' decision to pay the dividend free of income tax.

Owing to pressure on our space and the necessity for going to press earlier this week, some of our regular features are unavoidably held over.

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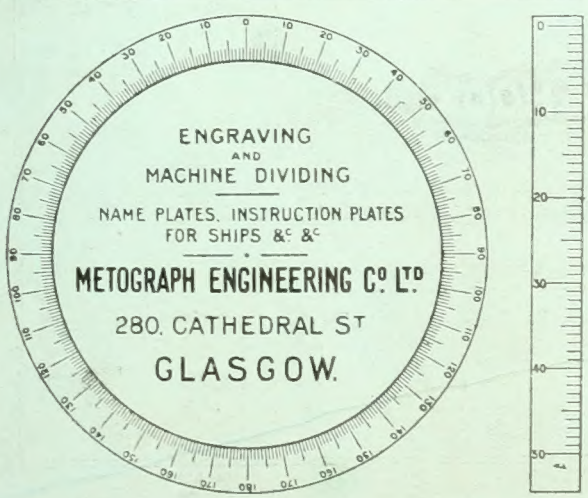

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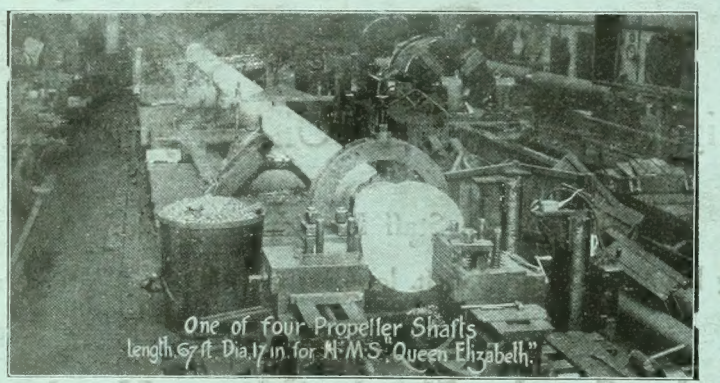

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